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THE SOCIETY is the growth of over forty years of achievement and leadership. Its members are engineers and technicians skilled in every branch of motion-picture film production and use, in television, and in the many related arts and sciences. Through the Society they are able to contribute effectively to the technical advance of their industry. The Society was founded in 1916 as the Society of Motion Picture Engineers and was renamed in 1950.

Membership in Sustaining, Active, Associate or Student grades is open to any interested person according to his qualifications. Information about membership, technical activities and standards and test films for the industry is available from Society Headquarters. Members residing in countries which participate in UNESCO may use UNESCO coupons in submitting membership payments in the event other means of remitting are not available.

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The President's Report

By NORWOOD L. SIMMONS, *SMPTE President*

[At each Semiannual Convention the Society's President customarily addresses the Society on matters accomplished, pending and projected. The President also introduces the Convention's opening luncheon speaker — see the next page. Also there are observations about the planning and programing of the Convention at hand; President Simmons' remarks related to the 86th Convention have been embodied in that story in the latter portion of this *Journal*. His general address is excerpted below.]

A Convention such as this one does not simply spring into being overnight. Its success is not based on last-minute inspiration but rather on dedicated, behind-the-scenes work. Besides the Society Officers elected with Convention and Editorial responsibilities, there is a corps of chairmen who deserve great credit. (See the Convention report beginning the news section of this *Journal*.)

Your attention may be called, especially, to the rather unusual group of papers assembled by Sidney Sternberg, with inspirational help from Barton Kreuzer — the two sessions on Space Technology and Image Sensing. These have drawn distinguished visitors from the electronics and missile industries to our Convention. It is my belief that we must not wait, in the Society, for these new potential fields of use of motion pictures and television to be thrust upon us; but must seek them out and join with them. If we do not, someone else will. Special thanks, therefore, are due Barton Kreuzer for his conception of this session, which dates back to when he was President of the Society.

We are watching today in the motion-picture and television industries a gradual fusion of two modes of entertainment. This carries with it a blending of the creative techniques used in the two industries. This is a healthy situation. Every sound stage in Hollywood that is not engaged on feature film production is in use filming TV programs with the overflow occupying stages that had been closed for years. In this connection your attention is directed to the two very interesting sessions on Television Equipment and Practices, scheduled for Thursday that were completely arranged well in advance of the meeting by the hard-working Topic Chairman, Ralph Harmon.

Engineers, as well as all craftsmen in the industry, such as the makeup man, the cinematographer, the editor, and so forth, have had to learn new techniques. If they do not adapt, they are lost. New breeds of engineering or technical specialists have been developed in much the same way as the television writer, who is now regarded as a separate form of literary creator. Demands for certain forms of engineering talent outstrip the supply. SMPTE can meet this challenge. For example: rapid introduction of video-tape recording as a technique for TV program production has created a shortage of editors skilled in handling this medium. The Society has been requested by the Motion Picture Film Editors, Local 776 in Hollywood, to conduct a course in this subject. The Education Committee of SMPTE has announced that such a course will be given, starting just after the first of the year.

Let us consider, for a moment, some developments in which the motion-picture and television engineer may take pride. Our *Journal* has chronicled, within recent months, the development of faster color films, new black-and-white films with improved speed-graininess ratio, ultra-fast cine camera and TV camera lenses, remarkably versatile variable-focus or zoom lenses, and great improvements in the quality of video-tape recording materials and equipment.

We have finally achieved some reasonable order from the many diverse camera techniques which employed various film sizes and shapes and resulted in various aspect ratios. This has benefited everyone, and especially the exhibitor. We have developed improved printing techniques, resulting in sharper, cleaner, and steadier images in the print film, than were ever obtained before.

There have been several new developments in the special-effects field, both for live TV and video-tape recording, where done electronically, and for motion-picture film production, where done photographically. These have vastly enlarged the possibilities for story enhancement without excessive cost. It has been commonplace in Hollywood for motion-picture producers to expect the well-nigh impossible from the special-effects craftsmen and to be greatly disappointed if they don't get it. Television program producers now rely on electronic wizardry in the same way.

We have talked about the entertainment field. What about the other large segments of our membership interest?

Recently an event of much importance to SMPTE took place in Washington, D.C. There has been much fine work by those planning for the Fifth International High-Speed Congress, notably by Messrs. Max Beard, Chairman of the Congress; and Wilton R. Holm, Secretary of the Society. A Resolution was placed before the United States Senate by Senator Warren Magnuson of Washington, Chairman of the Committee on Interstate and Foreign Commerce. This described the Congress, defined its purpose and called upon all government agencies to support the High-Speed Photography Congress (see the October *Journal*, pp. 706 and 711 for the complete Resolution).

The SMPTE expects, with the full cooperation of government and industry, to organize and conduct the Fifth International Congress in a manner which will bring credit and enhanced prestige to the United States.

At this Convention it was a special pleasure to have two guests from France: M. Fred Orain, President of the Commission Superieure Technique du Cinema; and M. Jean Vivie who is Secretary-General of the Commission Superieure Technique du Cinema and Secretary of the Association Francaise des Ingenieurs et Techniciens du Cinema.

The international scope of the Society's interests is reflected both in the increase in number of its foreign members and the affirmative and enthusiastic spirit which prevails among them. Certainly, credit is due the Foreign Membership Committee under the leadership of D. J. White. The Society is also appreciative of the high quality of leadership displayed in coun-

tries throughout the world. Two examples among many are: The Constitution and Bylaws of the Society are being translated into Spanish by Sr. Luis A. Reategui Aspajo of Lima, Peru, for use in membership recruitment in Spanish-speaking countries. In Italy, the Associazione Tecnica Italiana per la Cinematografia and its Administrative Secretary, Dr. Elio Finestauri, are sponsoring and promoting membership activity.

Although the Society is looking toward the future, recognition of the past is afforded by the Historical and Museum Committee which recently was requested to aid in the preparation of an exhibit of historical and contemporary samples of film for the Smithsonian Institute.

In the field of Educational Communications media, the Society has been laying the groundwork since last Spring for a study of the communications media and equipment needs of modern education, to be undertaken for the U.S. Office of Education, a Division of the Department of Health, Education and Welfare. Preliminary meetings have been held by a task force committee of SMPTE with representatives of the Office of Education, and arrangements are being completed for the Society to undertake this ambitious project.

With the growth of specialized applications of the motion picture and of television, and the consequent diversification of interests of our enlarging membership, the question naturally has often arisen: How can the Society properly satisfy the needs of such a heterogeneous group? This question represents the greatest challenge facing our Society today. We believe that the advantages to be gained by contact and exchange of information of all groups interested *broadly* in the imaging and recording of action and sound more than offset the disadvantages. The rubbing of elbows and the exchange of ideas, experiences and disciplines result in a broad base of knowledge that is wanted and needed by our members.

It is the responsibility of the elected officials of the Society, both nationally and locally, to provide in our programs and in our publications appetizing and nourishing fare for its members. It is the responsibility of the members to advise us if this is not being done.

Engineering in the Space Age

By EDWARD P. CURTIS

[From the introduction by SMPTE President Simmons at the Convention Get-Together Luncheon, October 5, 1959: Our speaker might be introduced from either of two successful careers. He has served the photographic industry for over thirty years and is a Vice-President and a member of the Board of Directors of Eastman Kodak Co. He is responsible for Eastman's motion-picture film business throughout the world and supervises Eastman's general business in Europe. In these capacities he has become acquainted with the problems and personalities of the world's motion-picture and TV industries.

He can also be introduced as a man highly distinguished in the field of aviation, beginning with service as a combat pilot in France in World War I. His interest in aviation took him into service at the start of World War II, and his distinguished military career terminated with his service as Chief of Staff of the U.S. Strategic Air Force in Europe where he attained the rank of Major General. Since the War he has held various appointive posts in Washington including special assistant to the President, for aviation planning in 1956. From this came a report of long-range planning to meet the complex problems of using the air in the jet age, a report for which he was awarded the Collier Trophy by the National Aeronautic Association.]

Our Society and its Conventions are primarily concerned with the engineering problems of motion pictures and television; at least they used to be. You have, however, recognized in setting the theme of this Convention that any engineering activity must be evaluated and considered in the framework of man's entry into the Space Age. The satellites at present orbiting the earth and other planets are dramatic evidence of the fact that there appear to be few limits to what science and engineering can accomplish in pushing out the frontiers of man's knowledge. It is significant too, I think, that these accomplishments are international in scope and by no means confined to the profession in this country.

If there have been doubts about whether this Society was fully aware of the implications of the Space Age, consider the papers being presented on the Space Technology and Image Sensing Sessions of this Convention. Just the titles are enough to frighten a layman; Image Sensors and Space Environment; Orbit Determination From Optical Tracking; Television and Lunar Exploration; . . . . What a business for engineers whom we used to consider primarily interested in the entertainment field! I can only hope that you do not get so preoccupied with space technology that you forget we need a few mundane things like better projection in motion-picture theaters and improved kinescope recordings.

One question which we in the entertainment business can certainly ask ourselves is whether engineering in these fields has kept pace with the spectacular achievements in the beginnings of the conquest of space. Certainly the members of this Society have a host of important and significant achievements to their credit since the days of 1916 when Francis Jenkins and a small group of engineers first met here in New York to consider the problems of a then young motion-picture industry. Foremost of these undoubtedly is the development of the television industry, then entirely unknown and now recognized by this Society and the entertainment world as at least on a par with the motion-picture industry; color pictures in both fields, stereophonic sound, wide-screen processes are only a few of the many outstanding developments for which our engineers are primarily responsible.

Future Engineering

And yet the feeling persists that in terms of application to the entertainment field our engineering achievements have perhaps lacked the imagination that has characterized man's advance in space. We haven't had a breakthrough, comparable to a Sputnik or a moon shot, to lift entertainment to new high levels since the advent of television. We have had improvements aplenty but nothing that has really given a startling new look to the art of entertainment. In saying this I confess I do not have in mind exactly what our engineers might have accomplished which they haven't done. Perhaps one simple example might be the development of three-dimensional pictures in color — needless to say without the use of glasses — but there must be many others.

I might hastily add, however, if we have had any shortcomings in this respect it is not primarily the fault of the engineers. Nor, I think, is it quite fair to lay it to the fact that the leaders in the field are not as sympathetic to the engineer and his problems as they might be. I have heard this opinion voiced

more often in motion-picture circles than among television engineers; but it comes from both, and there is some truth in it. This is basically, I am sure, because entertainment is not in any sense an exact science and never will be. Entertainment depends primarily on creative talent; the responsible producer is not to be blamed when he is more preoccupied with story properties and stars than he is with improving sound quality or with getting more speed and better definition in film. True, the best attraction can be all but ruined by poor projection, inferior color or bad television reception, but the finest technical achievements can't make good entertainment out of poor material.

Our International Industry

Earlier I mentioned that achievements in space were international in scope and not confined to this country, and this of course is true of our interests in this Society. The motion-picture industry particularly has always been a world-wide business, and now television is rapidly becoming world-wide. More than any other American industry, the motion-picture business derives a great proportion of its income from abroad and, for better or worse, probably has more impact on our relations with other peoples, or certainly on their ideas of how we live in the United States.

On a visit to Russia last August, my purpose was to see our U.S. Exhibit and not to study the motion-picture and television industries but I did learn incidentally a little about them.

Two of the outstanding attractions at our exhibit were the Circarama show, the 360° motion picture which was shown at Brussels but which at Moscow had some added sequences of Washington scenes which were excellent. The whole Circarama show is a thrilling presentation of the United States. The prints were too dark but I doubt if this bothered the customers very much. Supplementing the motion picture was a periodic projection in a large hall on seven big screens of still color pictures showing typical American scenes of cities, people, farms, factories and churches. The selection of pictures was good but they were presented at such speed as to be a little confusing.

It is not surprising that the picture presentations attracted so much attention because the motion picture is still the outstanding means of communication in Russia for entertainment, propaganda and education. Although television is becoming an increasingly popular entertainment medium the film industry is continuing to expand. There are 77,000 cinemas in Russia today; of these about 25,000 use 16mm film and the seven-year plan on which Russian industry is now working calls for the total number to reach 120,000 by 1965.

The whole industry is basically responsible to the Ministry of Culture although each of 15 republics of the U.S.S.R. has its own studio and processing laboratory. These vary in size and importance, the major production centers being in Kiev and Moscow. For national distribution the film must be dubbed into several different languages. The Russian engineers are much interested in 70mm film, and based on some test films they have made in 70mm Sovcolor they are convinced it has a great future.

The situation of our industry in Russia is interesting as almost everything in that country is to us at the present time; but it is no potential market in the foreseeable future for the products we make. I would guess that our sales of motion pictures, television sets or programs, raw stock or anything else will be on only a token basis for many years to come.

Fortunately for us, however, the rest of the world is much more receptive to the import of our entertainment products. In spite of exchange problems, quota restrictions and government subsidies, the motion picture is still pre-eminent on the screens of the world. Obviously the entertainment value of our pictures has universal appeal and the technical achievements contributed by our engineers are as important in, for example, Tokyo as they are in New York.

Television is just beginning to spread its wings on the international scene although amazing progress has been made in the last couple of years by those producer-distributors of programs who have made determined efforts to develop overseas markets. Some companies are now getting as much as 20% of their total gross receipts from abroad and expect to double this within the next five years. So far, I believe the producers of TV programs have not given the same attention to the possible international appeal of their material as the motion-picture producers have long been accustomed to do but apparently this has not been necessary as yet. The programs which have proved popular in the United States are enjoying the same success in overseas markets.

It is obvious then that the twin interests of our Society are international in scope to a greater extent than those of most other American industries. The achievements of members of this Society have had and will have in the years to come a tremendous impact not only here at home but on millions of people in other lands. Therefore, this places all the more on you the responsibility for seeing to it that our engineering keeps up with the challenge of the Space Age and that America's position in the international world of entertainment continues to be one of leadership. Moon shots and manned flights into space have great boxoffice attraction, and will continue to until they become commonplace, as they will doubtless do one day. Thirty years ago Lindbergh's transatlantic flight was the newspaper story of the year, but today the only transatlantic flight which could make the papers would be one which didn't get there.

I am not suggesting, however, that you should set your goals at competing with rockets and satellites nor can you afford the costly trial-and-error approach that has, perhaps necessarily, characterized our efforts in this field. Space engineers have access to the taxpayers' money which we in the entertainment business do not and I hope never will. What I do think we can learn from this fascinating world of astronautics is that there are no limits to the accomplishments of men's minds — no boundaries or obstacles which cannot be overcome if we have the will to do it. Many of these incredible developments have been forced on us by the sheer necessity of survival. To a very considerable extent fear has been the driving force which has pushed us forward and fear is not a good master.

Fortunately you have other motivations as motion-picture and television engineers — pride in your profession, pride of achievement and, I am sure, a determination to keep this country ahead in your chosen field. You have great inspiration in the miracles of present-day scientific achievements. I am confident that the members of this Society will fully measure up to the challenge of the Space Age.

Electronic Composites in Modern Television

By RALPH C. KENNEDY
and FRANK J. GASKINS

Various methods of "insetting" or creating a composite of subject and background in television have been developed. Chroma-Key uses a highly saturated color background for live TV composites. Equipment now used by NBC is described.

THE DEVELOPMENT OF special effects generated electronically is a natural part of the progress and growth of the all-electronic television broadcast system, first in monochrome and presently in full color. They are used for effecting smooth changes of scenes, transitions between different parts of a program, and providing interesting geometric patterns. More recently, the NBC-developed Chroma-Key electronic video inset technique has been utilized for increased flexibility in television program production.

Television was still in the monochrome flying disc era when a patent application was filed which described a means for producing fade-outs, fade-ins, and lap dissolves.[1] This made possible more artistry in changing scenes or mood in contrast to the sharp breaks which had previously been necessary.

A patent application filed in 1932[2] described a means of insetting the information from one television camera into information from another camera so as to produce a composite result. The term "inset" is used to describe the process whereby the brightness variation in the signal from a camera is used to delete a corresponding area from the picture from a second camera so that the first camera's picture will fit precisely in the "hole" thus created in the second camera's signal. Such a facility opened up many new possibilities. Since the background material could be any kind of art material, e.g., stamps, post cards, magazine illustrations, transparencies, film, etc., the cost of sets could be vastly reduced and much greater freedom was offered the producer.

The basic technique involves placing the subject material to be inset in front of a black background. The camera output is at pedestal or black level except when scanning the subject. The presence of the black-level output is used to generate a potential whose polarity is opposite to that of the potential produced while scanning the subject. These two potentials when shaped produce a pulse which is used as a switching means choosing the output of the background source when scanning black and choosing the output of the foreground or inset camera when it is not scanning black. The combination of the two video signals results in a composite picture when viewed on a kinescope. This technique was first demonstrated at NBC around 1940. In the demonstration, a girl sitting in a chair in front of a black background in a studio was "inset" in a film showing a box seat at a race track.

Another patent application filed in 1937[3] described a more complex type of composite wherein three separate and distinct planes of depth were combined so as to have foreground inset into middle or intermediate ground material which in turn was inset into the background material.

To understand how such a technique might be used, the following explanation is offered. A film of the front of a sidewalk cafe in Paris showing people entering and leaving is the background. A group of actors seated at a table is placed in front of a black background in the studio. This middle ground subject matter is picked up by a studio camera and electronically inset into the background film. Finally, a film showing autos, bicycles, trucks, etc., moving along the street is inset into the composite formed of the previously described intermediate and background subject matter. The only requirements for proper constitution of the whole picture are: (1) that the scanning of any middleground subject matter must key out correspondingly scanned background material; (2) that the scanning of any foreground material must key out correspondingly scanned middle and background data; and (3) the timing of the middleground and foreground signals with reference respectively to the timing of the "hole" deleted in the background and middleground data must be proper to assure minimum demarcation or transition between the inset and the background. The timing of the inset to correspond to the "hole" deleted in the background utilizes well known television practices for timing of blanking, horizontal and vertical drive, and synchronizing signals in a TV installation.

The most difficult condition to realize is to reduce to a minimum the line of demarcation between "inset" and the background. The switching action must be extremely fast, the transition symmetrical, and the shift of the d-c axis between the two modes must be less than 1% and retain that adjustment at least for the duration of a particular show.

Numerous circuits have been tried but it was not until 1952 that a satisfactory "switch" was described[4] which has made possible the various effects to be discussed. The switching amplifier will be described in greater detail under the section on "Apparatus."

The switching amplifier responds in accordance with the kind of keying signal fed to it. Thus, a square wave whose duty cycle may be varied provides split screen and wipe effects. Other signal information in proper combination can produce diamonds, circles, squares, etc., in a wide variety of geometric forms. The waveform generator for this purpose will be described under "Apparatus."

The inset technique may be extended for a greater number of depths or planes of action. However, there are certain problems arising from the use of this type of effect. One is a matter of lighting. The amount of light required to illuminate the black set is quite low. However, the light necessary on the artists is quite high, causing some discomfort due to heat. One way to circumvent the problem is by letting red velvet be used instead of black for the background material. The artists then use green make-up and garments and green illumination is used. Green filters are used on the cameras to permit use of the so-called complementary black in contrast to the true black.

The choice of black for gating or switching operation requires certain precautions to be exercised to prevent the appearance of background material in undesired portions of the picture. The artist cannot wear black clothing or have black hair. Neither may camera shots in close-ups where the performer speaks be utilized as the background material may appear through his mouth.

Another consideration which requires very close attention to detail is that of perspective. The various depths or planes of action must be so proportioned in size that when the complete composite picture is viewed, all components, both scenery and subject alike, are able to create the critical impression of depth or perspective to the eye.

Two additional contributions which are pertinent to the present discussion

Presented on April 25, 1958, at the Society's Convention in Los Angeles by Ralph C. Kennedy, National Broadcasting Co., RCA Bldg., Radio City, New York 20, and Frank J. Gaskins, National Broadcasting Co., Burbank, Calif. This is a slightly revised version of the paper first published in the *Proceedings of the IRE*, November 1958, pp. 1798–1807.
(This paper was received July 2, 1959.)

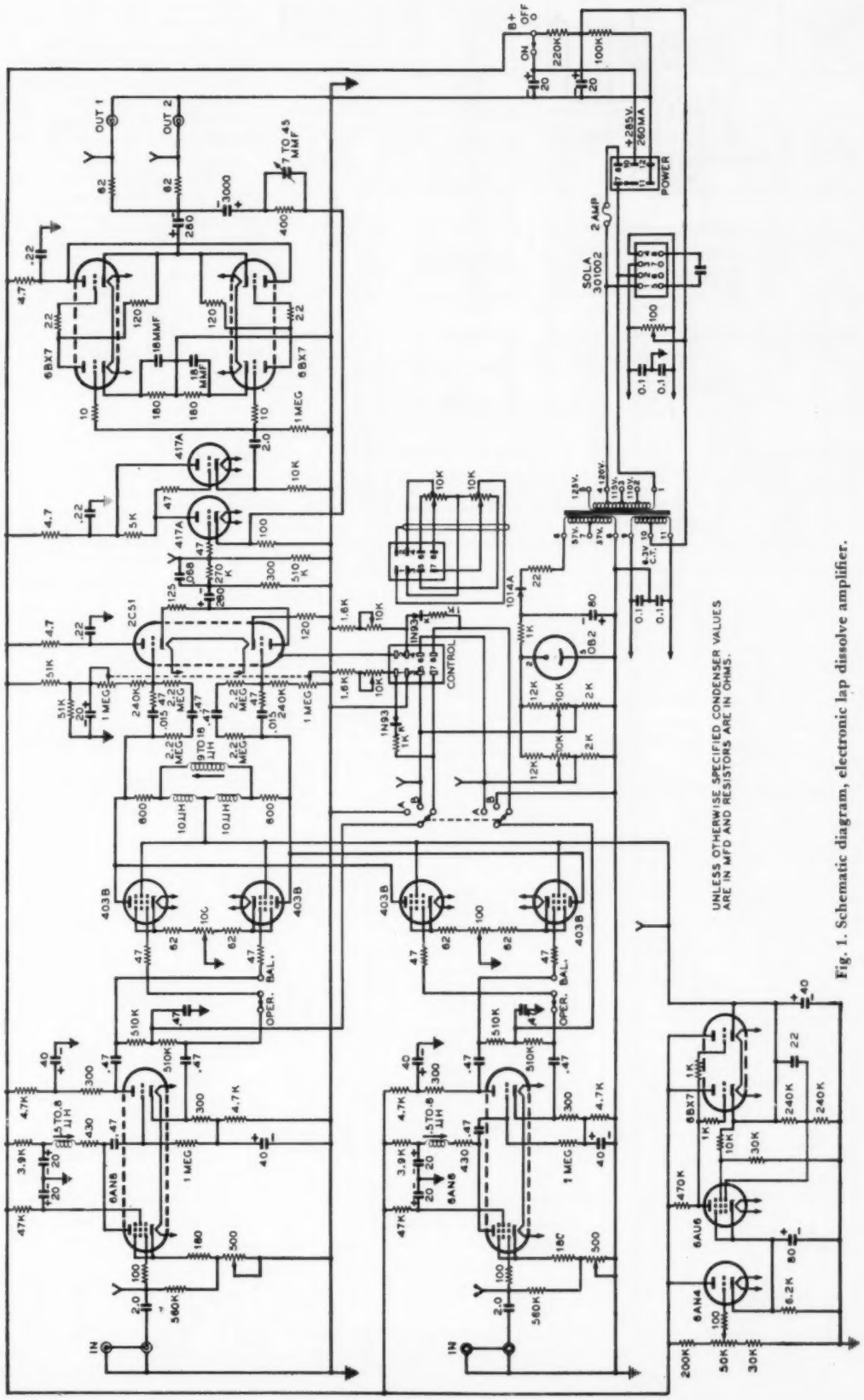


Fig. 1. Schematic diagram, electronic lap dissolve amplifier.

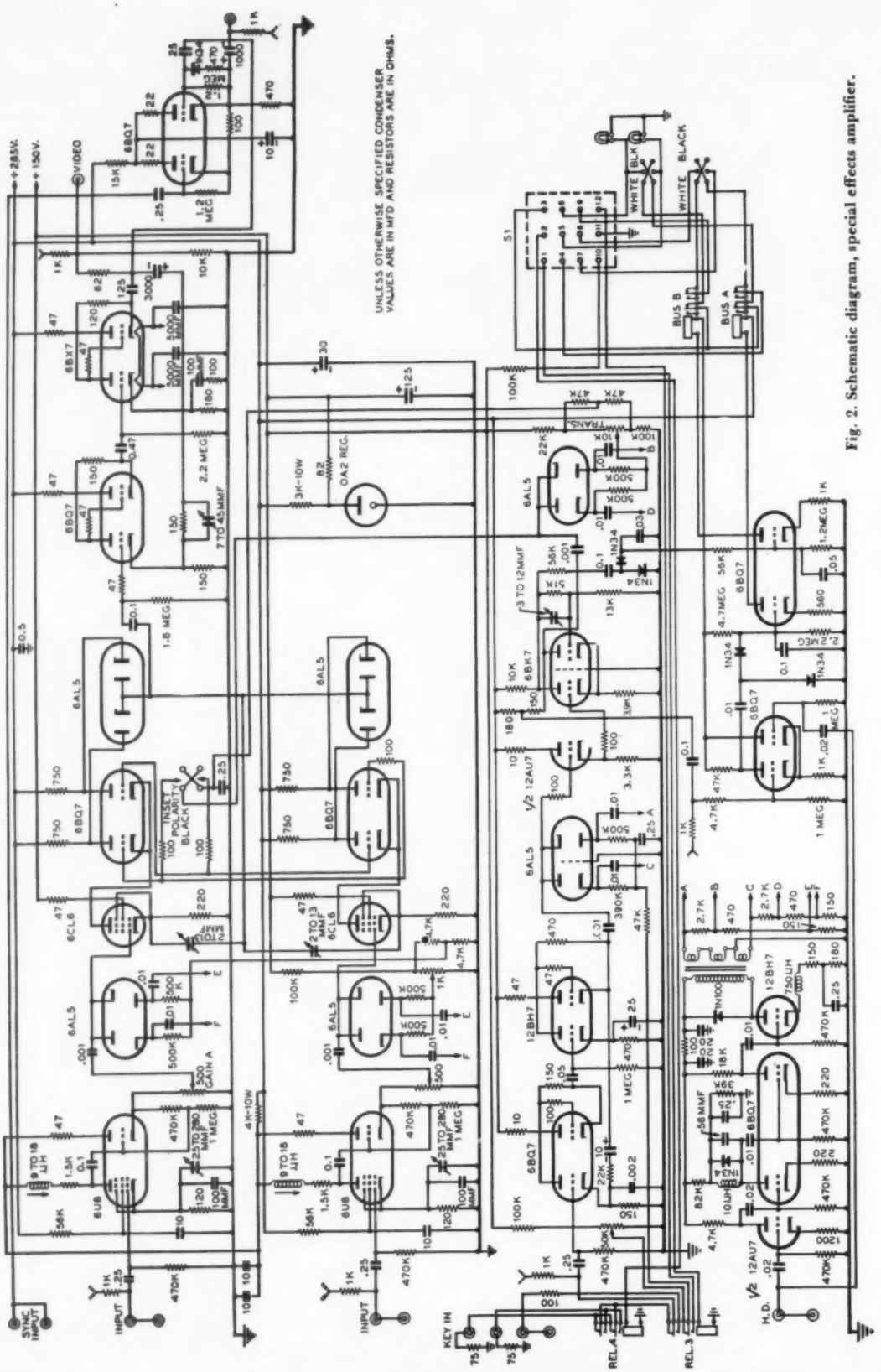


Fig. 2. Schematic diagram, special effects amplifier.

are covered by patent applications filed in 1935[5] and 1939.[6] The first patent describes the use of geometric patterns, e.g., circles, stars, diamonds, etc., on slides placed in a slide scanner (or viewed by a TV camera) for generating keying information. The geometric figures may be white on black background or vice versa. In this arrangement two signals, either from cameras or other program sources, are fed into the switching amplifier. The signal from the slide scanner or a TV camera then keys one program source into the other in accordance with the shape of the geometric design in the slide scanner.

The second patent covers the basic idea of using one camera to scan some geometric design for addition to a picture from some other source. The resultant picture would have the geometric design either black or white inset into the picture. However, the unique feature is that the inset figure might be a small arrow which may be moved about in the picture into which it is inset. With this facility, it is possible to point out an individual in a crowd such as is done in televising political conventions, etc.

Chroma-Key Electronic Video Inset

All of the methods discussed briefly thus far have been used primarily in monochrome television. The teachings are applicable equally to color television and many are presently in use today on color programs. It is obvious that the complementary black approach using red background material and green subject material cannot be used for color television, but the use of conventional black backgrounds with amplitude differentiation between inserted and background material has been effective.

The color signal is of such nature as to suggest two other methods for deriving the keying or switching data. As is well known, a color signal from the camera is actually in the form of three separate signals. In the colorplexer or encoder, these are combined in proper fashion together with the reference burst to form a single output signal. Either the signals at the input to the colorplexer or the waveform from its output may be used to generate a pulse suitable for switching.

The Chroma-Key electronic video inset technique differs from the technique employed in monochrome television in the broad sense in that differentiation between the foreground and background material is accomplished by differences in hue rather than differences in amplitude. A matrix and white balance circuit used to select the proper hue of the background, e.g., blue, to generate a pulse followed by a high degree of nonlinear amplification, creates the switching signal when it is desired to derive it from the signals entering the colorplexer. The color signal analyzer or its equivalent is used to properly phase to and recover the necessary switching information from the colorplexer output signal.

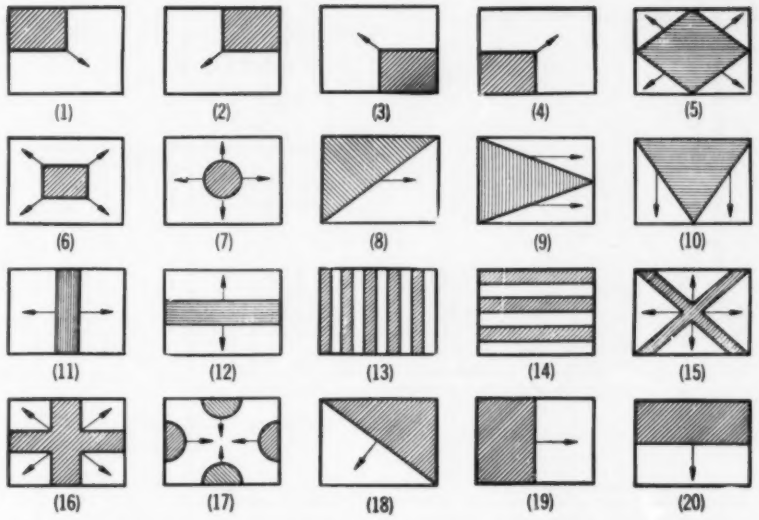


Fig. 3. Waveforms to permit generating split screens on vertical, horizontal and diagonal bases, circles, venetian blinds, inset squares of adjustable size and location in the field, and others produced by Keying Generator.

Apparatus

Lap-Dissolve Amplifiers: As has been apparent from the above discussion, there are several pieces of apparatus needed to create all the various effects which have been described. Lap dissolves, fade-ins, fade-outs and superimpositions are effects which can be produced by means of the lap-dissolve amplifier. The circuitry of the lap-dissolve amplifier presently in use is shown in Fig. 1. Basically, the objective in these circuits is to provide a means whereby manual control is used to select the amount of signal from each of two cameras or sources of video information prior to their being added in a common impedance. At one end of its travel, the manual control has effectively turned off one camera's output and turned on the other. The converse is true when the control is at the opposite end of its travel. For positions intermediate the output of each camera is contributing a fraction of its maximum and the resultant picture has the appearance of a double exposure. Placing the control in the middle of its travel permits half of each camera's output to be seen and a superposition is created. Operation of the control slowly from one extreme to the other produces a lap dissolve. If no video signal appears at one input of the amplifier, operating the control from this channel to the other produces a fade-in and the converse action produces a fade-out.

Special-Effects Amplifier: Several circuits have been used for this type of operation but the most satisfactory one presently in use is shown in Fig. 2. As may be seen, the amplifier is capable of accepting two video signals and of being able to switch between them at a very fast rate.

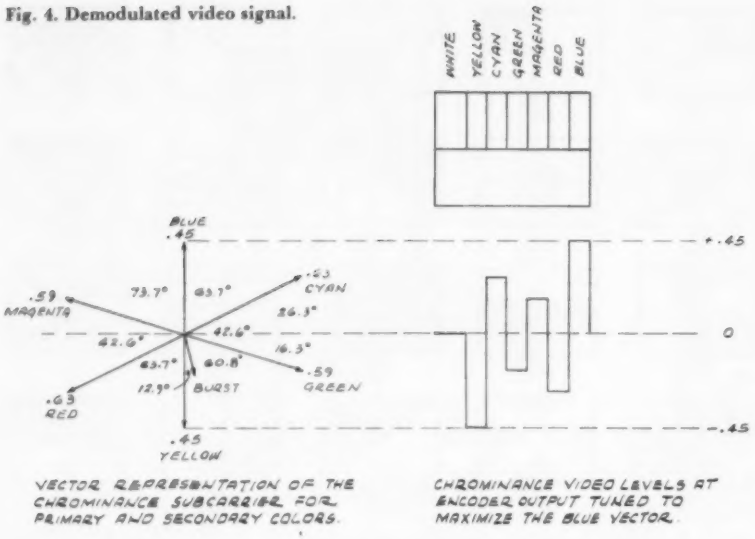
In Fig. 2, one video input is through V4 and clamp diode V5 to the switch driver V6. The second video input is through V9 and clamp diode V10 to switch driver V11. The switch comprises tubes V7, V8, V12, V13 and V15. The output circuit is a feedback amplifier V2 and V3. Application of about 5 volts of short rise time step causes the switch to operate and the opposite sense step returns the switch to its original mode. The rise time of the applied step should be somewhat less than 0.1 μsec. The capacities in the switch are such as to limit its action to approximately 0.1 μsec and the drive signal should be of shorter duration so as to avoid increasing switching time.

The signal from the camera picking up the subject in front of the black background is used to operate the switching amplifier. This camera signal is fed into the "Key In" bus and is formed into a pulse suitable for driving the switch by means of V19, V20, V21, V22 and V18.

Special-Effects Generator: The Special-Effects Amplifier can be used not only for insets but for producing a wide variety of geometric effects provided proper types of keying signals are supplied to the switch.

A special piece of apparatus, a "Keying Generator," has been developed for producing the requisite waveforms. Circuits are provided which produce sine waves, saw teeth, variable duty cycle rectangular waves of various multiples of field and line rate. These various waveforms permit generating split screens on vertical, horizontal, and diagonal bases,

Fig. 4. Demodulated video signal.



circles, venetian blinds, inset squares of adjustable size and location in the field and many others as shown in Fig. 3.[7]

The Chroma-Key System

In reflecting upon the limitations of monochrome inset it becomes apparent that the basic problems stem from low-light areas resulting from low subject reflectance, shadows, surface contours and subject lighting conditions in general. For proper switching operation, it is necessary that a large brightness difference be obtained between background and subject matter, and that this difference be translated into a large video signal increment. Thus, as has been pointed out earlier, extreme care is required in subject lighting.

If the situation is reversed wherein the unlighted subject is placed between an evenly lighted white backdrop and the camera, the silhouette formed could be easily utilized for deriving keying information for the switching amplifier, and shadows, subject reflectance, motion, etc., would no longer present a problem. This method would be excellent for creating silhouette effects but rather limited in application. It is this silhouette effect, however, which when used with a backdrop of a particular color that gives rise to the possibility of Chroma-Key. The subject is placed in front of a brightly lighted backdrop of a highly saturated hue. The subject may wear any colors other than color used in the background.

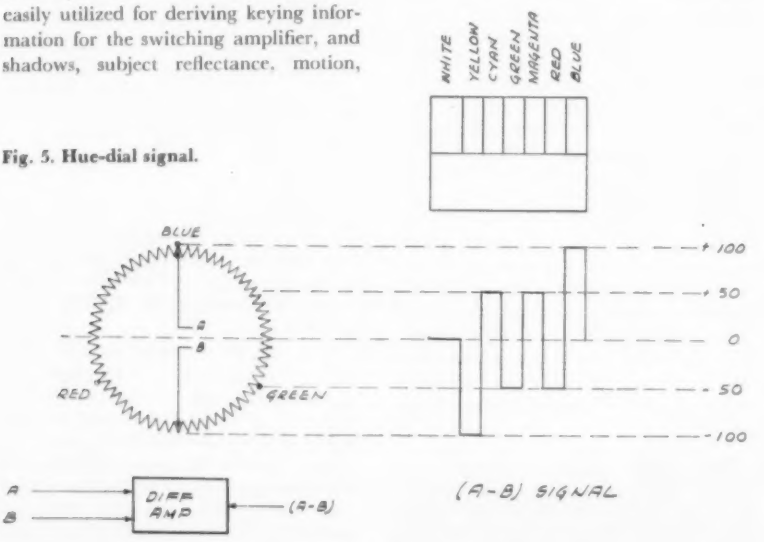
To understand how the background hue may be used to produce a keying signal, consider Fig. 4 which shows the vector representation of the chrominance subcarrier for primary and secondary colors in the color TV system, together with the corresponding chrominance video levels for an encoder tuned to maximize the blue vector. Such a signal might be obtained by introducing the output of a color bar generator into the red, green and blue terminals of a colorplexer or encoder. The encoder output is then demodulated in a circuit such as a color signal analyzer, the heart of which is a synchronous detector and calibrated delay line. By proper adjustment of the color signal analyzer, the amplitude of any particular color either primary or secondary may be maximized either positively or negatively. Thus the signals for all colors in the lower half of the vector polygon are negative. Furthermore, it should be observed that black, gray, and white are all at zero amplitude. Hues above the zero line are sufficiently differentiated from blue to allow positive keying. This indicates that, assuming a highly saturated blue background, whites, grays, blacks, all hues in the lower half of the polygon of Fig. 4, as well as some low-saturated colors in the magenta and cyan region may be used as subject material.

It is apparent that excellent color differentiation is present in the video waveform for certain hues. Saturated blues and yellows, for example, yield positive and negative maximum signals respectively, thus offering a very positive color difference signal for keying.

If it is desired to inset, for example, a yellow subject into some background picture, place the subject before an evenly lighted blue backdrop and use the camera signal after encoding to produce a positive blue waveform to key the special effects amplifier.

A second method, the "hue dial" shown in Fig. 5, consists of a three tap continuously wound potentiometer with two wiping contacts spaced 180° apart. As indicated in Fig. 5 red, green and blue primary signals from a low-impedance driving source are applied to the three input terminals. The output signals from arms A and B are connected to the input terminals of a differential amplifier which combines these into an A-B output signal. This signal upon further processing becomes the keying signal to operate the switching amplifier. For equal R, G and B input signals, i.e., whites, grays and blacks, there is no current flow in the arms A and B and the output is zero for all positions of A and B. However, when the camera is scanning, for example, a highly saturated blue area, the input to the potentiometer is R = 0, G = 0, and B = 1. Proper positioning of arms A and B results in a maximum output signal of +1. The amplitudes for other primaries and secondaries are listed below for blue maximized.

Fig. 5. Hue-dial signal.



Red	R = 1, G = 0, and B = 0
Magenta	R = 1, G = 0, and B = 1
Green	R = 0, G = 1, and B = 0
Cyan	R = 0, G = 1, and B = 1
Yellow	R = 1, G = 1, and B = 0

Red	Signal Amplitude −0.5
Magenta	Signal Amplitude +0.5
Green	Signal Amplitude −0.5
Cyan	Signal Amplitude +0.5
Yellow	Signal Amplitude −1.0

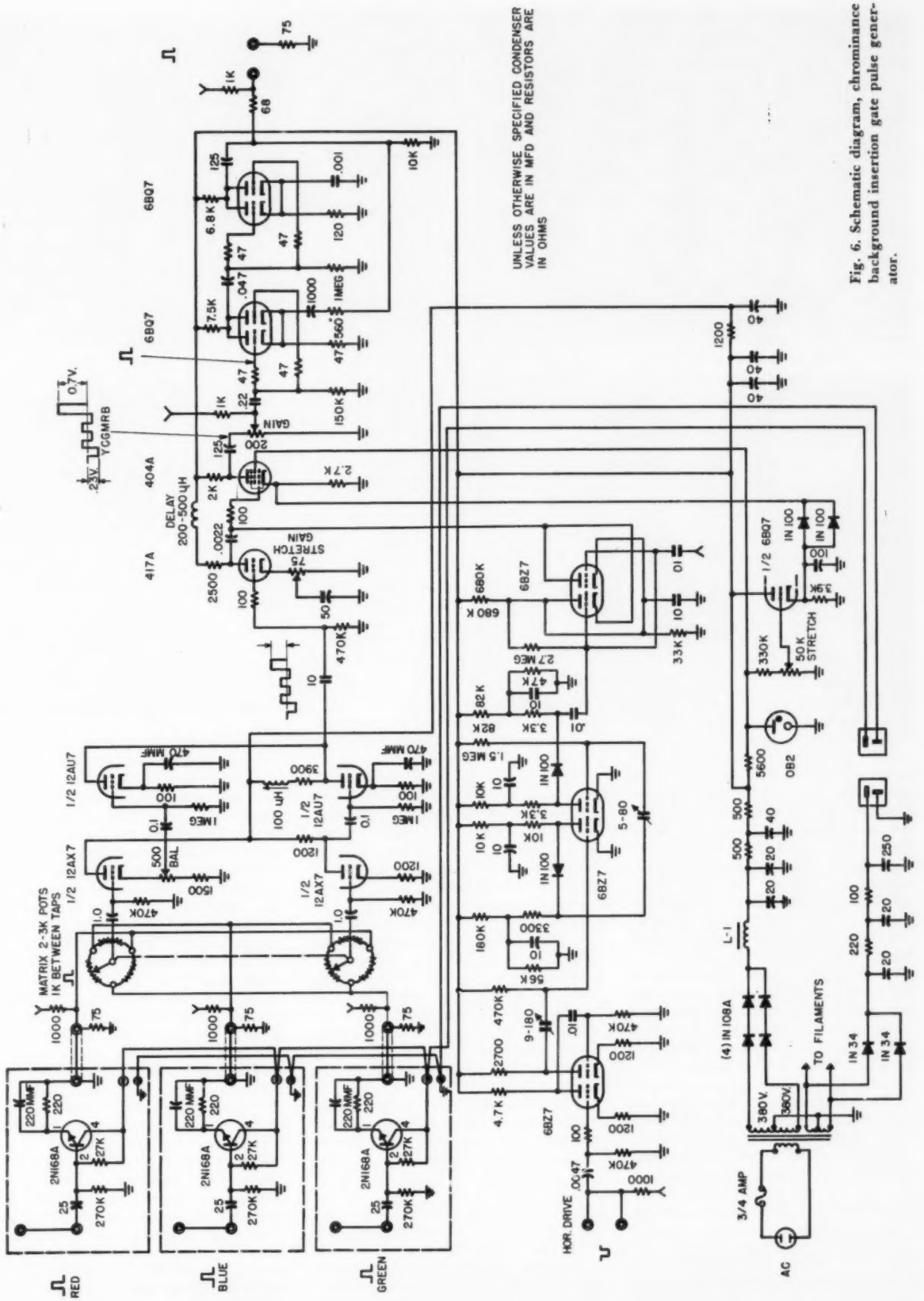


Fig. 6. Schematic diagram, chrominance background insertion gate pulse generator.

This method of hue selection for developing the keying signal is much more desirable than using the encoded signal. The difficult delay problems associated with the latter are nonexistent and the apparatus is simpler. At present, the "hue dial" is used in all NBC Chroma-Key equipment.

Processing of Matrixed Signal

In early versions of Chroma-Key apparatus, the matrixed signal was simply amplified, delayed, and applied directly to the switching amplifier. However, it has been found that in some instances this procedure has had to be modified in order to realize optimum performance. Since the switching amplifier must switch in intervals of 0.1 μsec, the signal causing it to operate must be a rectangular pulse having short rise time and a flat top. Experience showed that some camera tubes had landings which bowed and thus caused unreliable keying action on the edges of the picture. A tube having flat landing has constant output over all of a flatly lighted surface. It became apparent that additional signal processing was necessary to assure optimum operation. One technique which has been adopted is gamma stretching so as to raise the desired gating data as far above the remainder of the signal as possible. The desired signal is stretched 6 to 8 db above its normal value.

Chroma-Keyer

Figure 6 is the circuit diagram of the Chroma-Keyer. Emitter followers are used at the input of the encoder to feed R, G and B camera signals to the keyer proper. A dual ganged, continuously rotatable, tapped potentiometer forms the matrix. The two signals from the A and B arms of the potentiometer are amplified in an RCA 12AX7 amplifier. The signal is fed to an RCA 12AU7 differential amplifier where all luminance components are balanced out. A WE417A tube amplifies the signal and applies it to the clamped grid of a WE404A tube used as a gamma stretch or nonlinear amplifier. Two RCA 6BQ7 tubes form a feedback amplifier output circuit. Three RCA 6BZ7 tubes are used to control the delay and width of the clamp pulses. Two Sylvania 1N34 germanium diodes rectify a portion of the 6.3-v filament current to provide 1.75 v d-c at 5.5 ma to power the transistor emitter followers.

The output of the Chroma-Keyer is approximately 0.7 v peak for highly saturated color bars. The level is about 0.3 to 0.5 v for the usual camera output for a well illuminated highly saturated blue background. Figure 7 shows the Chroma-Keyer waveforms for various adjustments.

Scenic and Lighting Requirements

Since so many factors tend to influence the overall end result in a color composite, it is felt necessary to try to discuss the esthetic factors as well as the purely technical.

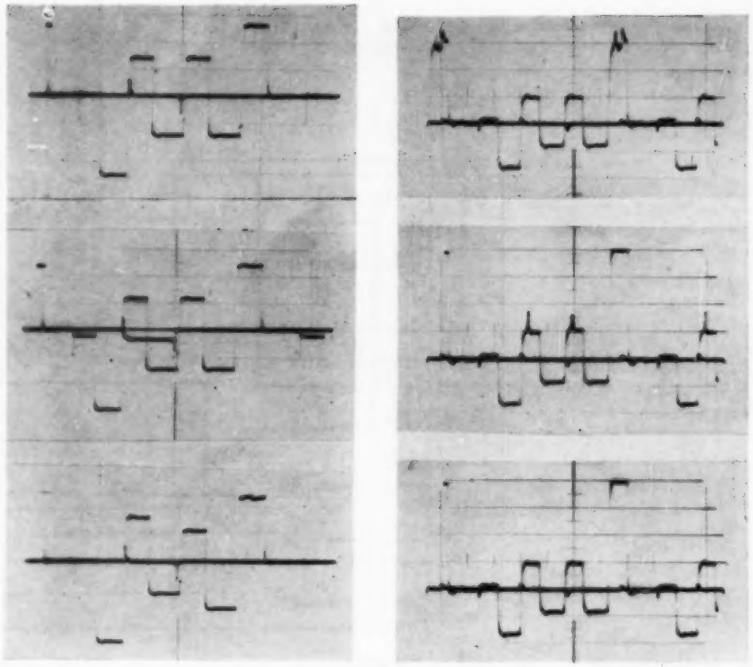


Fig. 7. Chroma-Keyer waveforms.

From top to bottom: Properly adjusted unit showing cyan and magenta at one-half amplitude and blue at full amplitude with white balanced to zero. Matrix properly adjusted and white balance misadjusted. Matrix improperly adjusted with white balanced to zero. From top to bottom: Insufficient blue stretch. Excessive blue stretch. Properly adjusted blue stretch.

The success or failure of Chroma-Key depends to a large extent upon lighting. The set used for the inset portion of the composite picture, i.e., the blue area before which the artist performs, must be very flatly lighted. If the full length of the artist is to be inset, the floor as well as the backdrop must be blue and very flatly lighted. This requirement must be met for all conditions. Full skirts on dancers cast shadows on the floor which may cause keying action with consequent loss of the legs of the dancer. It is for this reason that side lights and strip lights on the floor are highly desirable. It has been found that about 400 to 500 ft-c of light is necessary over the whole area to be inset.

It should be appreciated that the light on the subject itself should be completely independent of the background lighting requirements. The subject may be completely unlighted so that only a silhouette results, lighted on one side only, or any other way to meet the requirements for dramatic effect so long as it does not cast strong, hard shadows on the background.

With the above lighting requirements, it is obvious that the larger the set the greater the difficulty one must expect. This is especially true for dancing and other forms of rapid motion. The largest set which has been used thus far was 20 ft high and 56 ft wide, but only one person was on the set walking slowly toward the camera. More flexibility is realized with a set about 12 ft high and 20 to 25 ft wide.

It should be realized that there is a very definite limitation on the size of a set which is a function of the television system itself. The larger the set, the further a camera must be from the subject. In other words, the larger the set the smaller will the subject appear. Since the transition interval between the background and inset material cannot be any less than approximately 0.1 μsec due to the bandwidth of the televi ion system itself, the subject must be several times that interval in width at its narrowest part, e.g., an arm or leg. In other words, the line of demarcation around the subject is of sufficient width to effectively limit the minimum size which a subject may approach.

The color of the paint used on the background and floor; and the care which it must be given are both very important. Only water soluble paints are used and these have very low light reflectance. The color of the paint should be very highly saturated and should be as close to a primary color as possible. Since the subject to be inset is usually a person, the color of the paint should be as unlike flesh as possible, from the color television system point of view. This is

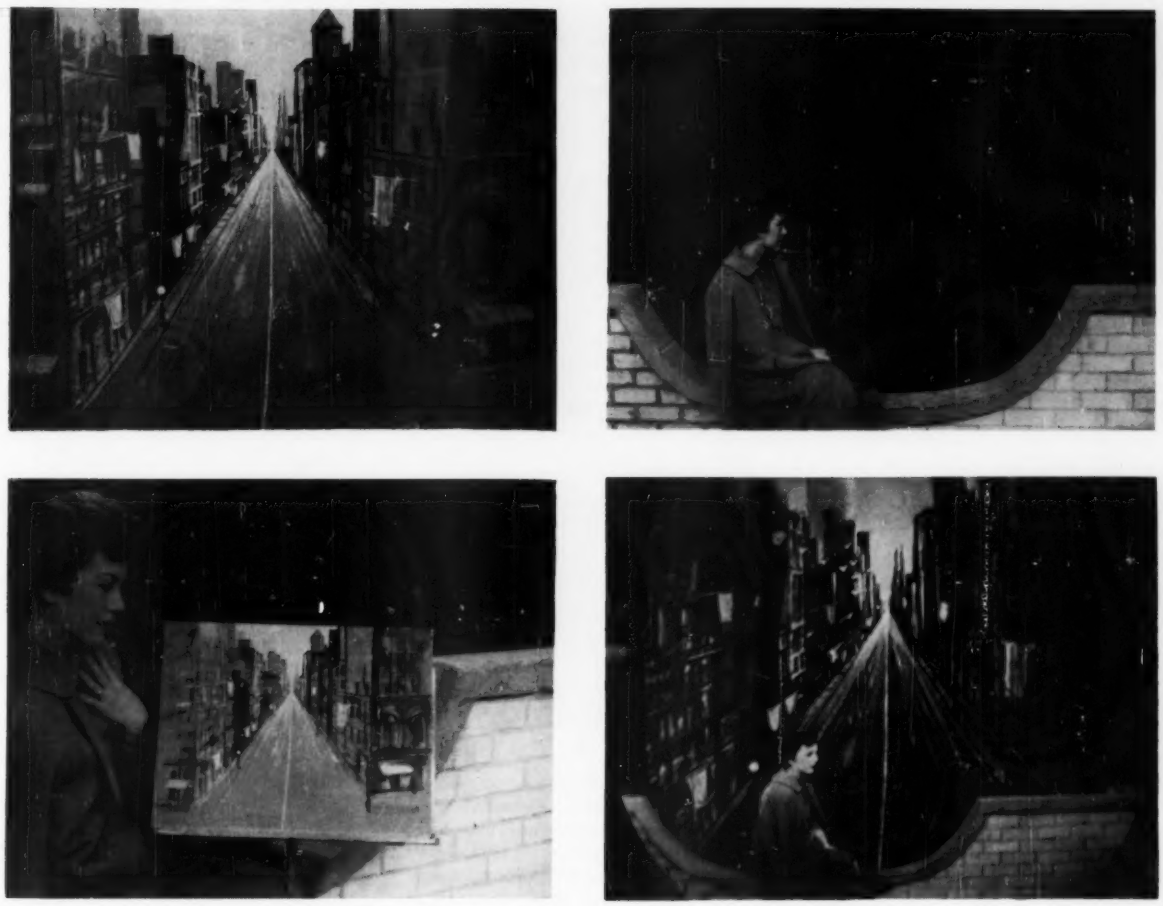


Fig. 8. Range of latitude and effects possible with Chroma-Key.

the reason why blue has been discussed previously. The paint which has been used most successfully is Iddings-Ultra Marine Blue. It is used as it comes from the can with no foreign matter added. This means that no other paint, thinner, or pigment, even white, may be added. Experience has shown that even the addition of white paint can be disastrous.

The care of the painted surface is also very important. Actually, the painted surface is quite fragile since it is water soluble. Dust from shoes alters the color sufficiently to cause tearing of the inset. Shoe soles should be washed and the floor surface should be repainted after each rehearsal. If dancing or other excessive action is to occur, the surface should be dry mopped between numbers during the show.

Obviously blue cannot be used for all purposes. If a product being advertised has a label with blue in it, then it must be placed in front of some color which does not occur in the label.

Graphic Art Considerations

The great use for the Chroma-Key technique is based on the wide diversity of its application. No longer is it necessary to build a huge set of the Taj Mahal to produce the effect of its presence in the studio. A very small model, slide, or motion-picture film can be used in lieu thereof and by proper proportioning of the camera angle widths, it is possible to make it appear that a person is walking in front of the building.

One such sequence was made using a small model of the pearly gate of Heaven about ten inches high. One camera was on the gate while another camera picked up the subject in front of the blue background. The effect produced as the subject walked forward was one of walking through the gate. The gamut of such possibilities is endless.

Films afford a tremendous variety of effects. Film of waves breaking on a shore has been used as background material with the inset subject walking on the beach. Another film of a stretch of road with curves, etc., has been used for background with the inset subject riding a bicycle along it. In addition to models and film, magazine illustrations, posters, post cards, transparencies, slides and stamps are all suitable for background material.

Artist's Effects

No discussion of the Chroma-Key technique would be complete without a consideration of the subject, artist, or performer and his effects. Experience to date has shown that blue eyes are not a source of trouble even though the blue background is used for generating the keying signal.

Clothing can be a very difficult problem especially sequins and jewels. They tend to break white light into a continuous spectrum and the blue then causes keying. The same results have been noted for white patent leather, white satin, diamonds, and other forms of jewelry. Satin and patent leather may be powdered to reduce glare. Obviously, blue clothing is impossible. The same situation would exist for other background colors should they be used. It is felt that all sequences or numbers which are to use the Chroma-Key technique should be given full dress rehearsal from the beginning.

Conclusions

While it is too early to predict the actual savings in set construction, painting and lighting, it is evident that Chroma-Key represents a powerful technique for color television. So far, it has been used on a number of programs including *Perry Como Show*, *George Gobel Show*, *Steve Allen Show*, *Standard Oil Co. 75th Anniversary*, *Hit Parade*, *Matinee Theater*, and many others. Additionally, numerous tests and experiments are being carried on to explore further all possible applications and limitations.

Figure 8, printed here in monochrome, was in four colors for the oral presentation to show in a small way the range of latitude and the startling effects which may be realized with Chroma-Key.

Acknowledgments

To try to give credit to all of those who have contributed to the development of various composite effects for television would certainly be next to impossible. The list of names of those who have contributed significantly to the successful development of various techniques at NBC alone is overwhelming. However, there are a few whom it would be remiss to pass over completely.

Dr. Alfred N. Goldsmith has given considerable time to guiding the preparation of this paper. A. L. Hammerschmidt, NBC Vice President Engineering and Facilities Administration, must be credited with making this investigation possible. Edward P. Bertero, Staff Engineer, has spent a great amount of time in testing various techniques in studios and evaluating the Chroma-Keyer as it has evolved. Considerable credit must be given to Henry Ball and Robert Pierce of the NBC West Coast Division for their work in development of the "hue dial" for its use in that branch of NBC.

Credit is also due those in the NBC Scenic Design and Graphic Art Departments for valuable suggestions.

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Interconnection of Studios for Video-Tape Recording

By R. W. GAST

The video interconnection of separate studios and tape centers is accomplished with wideband channels similar to those supplied to broadcasters and closed-circuit users. The art has progressed to a point where pictures can be transmitted for thousands of miles, when local and intercity facilities are combined. The local cable facilities are supplemented with portable microwave systems to care for temporary and occasional demands for service.

THE PRESIDENT of the Film Producers Association of New York, Nathan Zucker, was recently quoted in the press* as saying that film producers are more intrigued with video tape and its potential than is any other group. Tape is one of the many tools that producers can use to achieve their objective of outstanding pictures for television broadcasting.

The film producer who plans to add tape is faced with new problems of space, cost, operation and administration. In some cases, the decision may be to divide the equipment, placing TV cameras on his present stages and tape machines at some remote point. The video interconnection of separate studios and tape centers is the subject of this paper.

Historical Background

Many years before television, the Bell Telephone System was providing high-quality circuits to the broadcasting and recording industries for transmission of music and speech. These audio circuits ranged from short lines between studios in one city to extensive nationwide networks. When television broadcasting started, the telephone company began to provide a similar type of service to transmit picture information. A few wideband TV circuits for broadcasters were in operation as far back as 1938. After World War II, as commercial telecasting grew, the Bell System's service expanded until today there are many thousands of miles of video network lines crossing the country, as illustrated in Fig. 1. These routes provide service to hundreds of broadcasting stations.

The media of television inspired many nonbroadcast applications, and the same kind of facilities are being used to supply channels for special closed-circuit applications such as to audiences in theaters, hospitals, schools and hotels, and for many types of business use. In large cities such as New York and Los Angeles there are hundreds of local video channels, some connecting with the nationwide networks and others interconnecting points within the same city.

Figure 2 shows some of the principal video routes in New York. Telephone buildings strategically located throughout the city form the backbone of a special cable system. From each telephone building other special cables not shown extend to buildings served in the vicinity. The heaviest concentration of video service exists in and around the midtown theatrical district where many broadcasting studios, hotels and the like are situated. Connections to the nationwide network are made at a television operating center located at 32 Avenue of the Americas. This urban network of video cables has been constructed to meet specific needs of those desiring the service. It is constantly being expanded to care for new lines and new customers.

Video Cable

Conventional telephone wires and cables are not suitable for standard video transmission, so it is necessary to install shielded lines which satisfy the stringent technical requirements for good pictures. Each line employs a pair of 16-gauge wires, insulated with polyethylene and enclosed in a double shield of copper tape. The video pair is different from coaxial cable in that it uses two wires. As many as 24 video pairs may be combined in a single large cable sheath, and the complete cable may include

A contribution submitted on October 21, 1959, by R. W. Gast, New York Telephone Co., 140 West St., New York 7. The substance of this paper was presented on October 19, 1959, to the Film Producers Association of New York.

* New York Herald Tribune, Sept. 13, 1959.

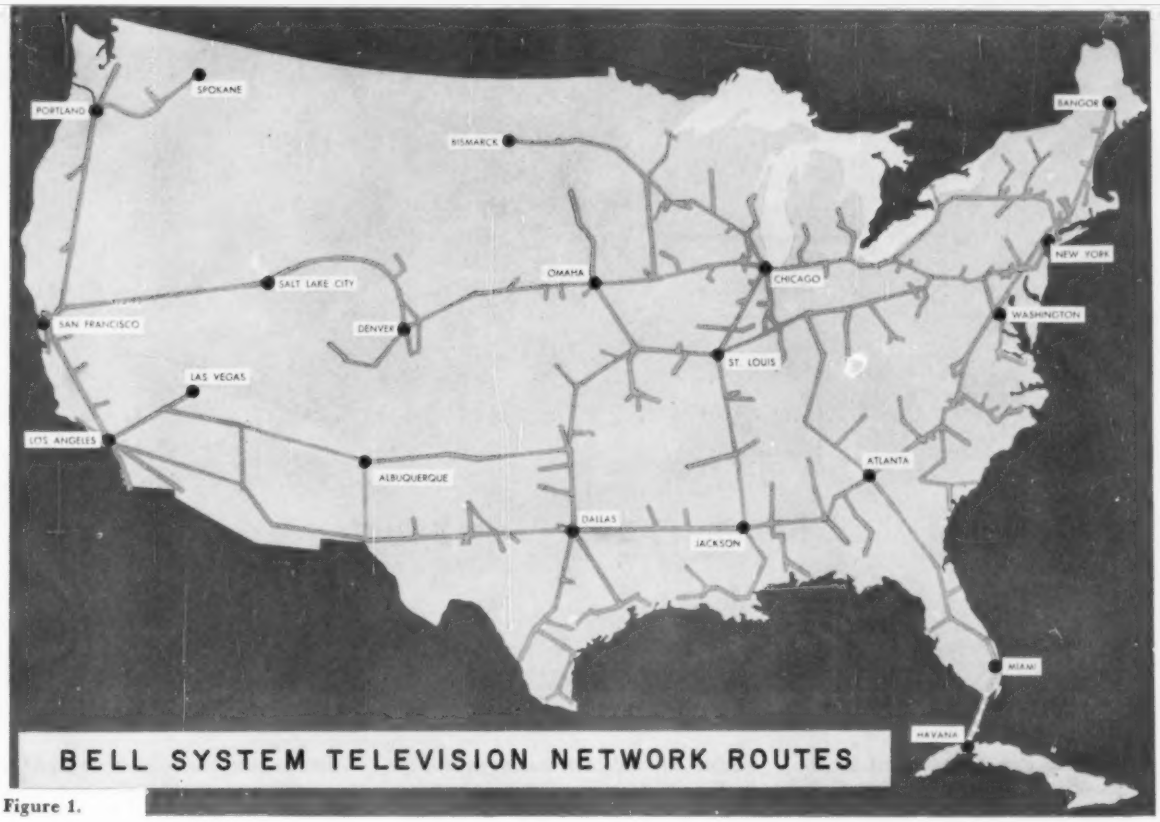

Figure 1.

other wires for regular telephone service. Externally it looks like a standard telephone cable, being built to withstand exposure in underground ducts and in buildings.

Technical Requirements

Video transmission is very exacting because the electrical signal which is transmitted must provide three major essentials:

(1) *Picture Information.* The detail of the scene being transmitted is furnished by the varying electrical impulses representing each of the thousands of tiny picture elements.

(2) *Synchronizing Information.* The starting point for each line and field must be indicated to keep the many picture elements in the same relative position as they were in the original scene.

(3) *Color Information.* If a program in color is involved, the television signal must also give information relating to the proper hue and intensity.

To meet these requirements and transmit the video signal faithfully, the line facilities must be capable of carrying a very broad band of frequencies in order to provide picture information corresponding to the fine detail in the televised scene. The local channels normally used have a bandwidth nominally from 60 cycles/sec to 4 mc/sec. Throughout this band all frequencies must be transmitted equally well; in other words, the channels must have a "flat characteristic."

Another consideration is "phase" or time delay. The various elements of the signal must maintain their relative position; components of the complex signal which start out together must reach their destination at the same instant, otherwise there would be distortion in the picture or, if color were being transmitted, possibly the wrong hue. The facilities must be "linear," that is, changes in the signal at the distant end must be in proportion to those at the input, so that a correct range of picture brightness, gray scale, or depth of color will be maintained.

Lastly, the line facilities must be insensitive to electrical interference which would cause picture noise. A picture may be impaired by electrical disturbances of extremely small value, sometimes only one millionth to one ten-thousandth of the strength of the video signal. As those in the film industry know so well, the human eye is amazingly sensitive to the slightest imperfections.

So far only technical requirements have been discussed. Another consideration is the manner in which the interconnecting lines are employed. The needs of users vary from day to day, even from hour to hour. In the case of broadcasting, it is possible that several local circuits will be connected in tandem according to the routing desired at any given time; these circuits in turn become part of a nationwide hookup. For such an arrangement to produce satisfactory results each individual unit must be of the highest quality and must be kept in excellent working order.

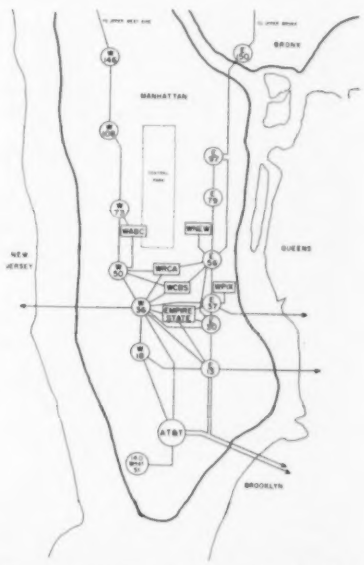

Fig. 2. Principal video routes in New York.

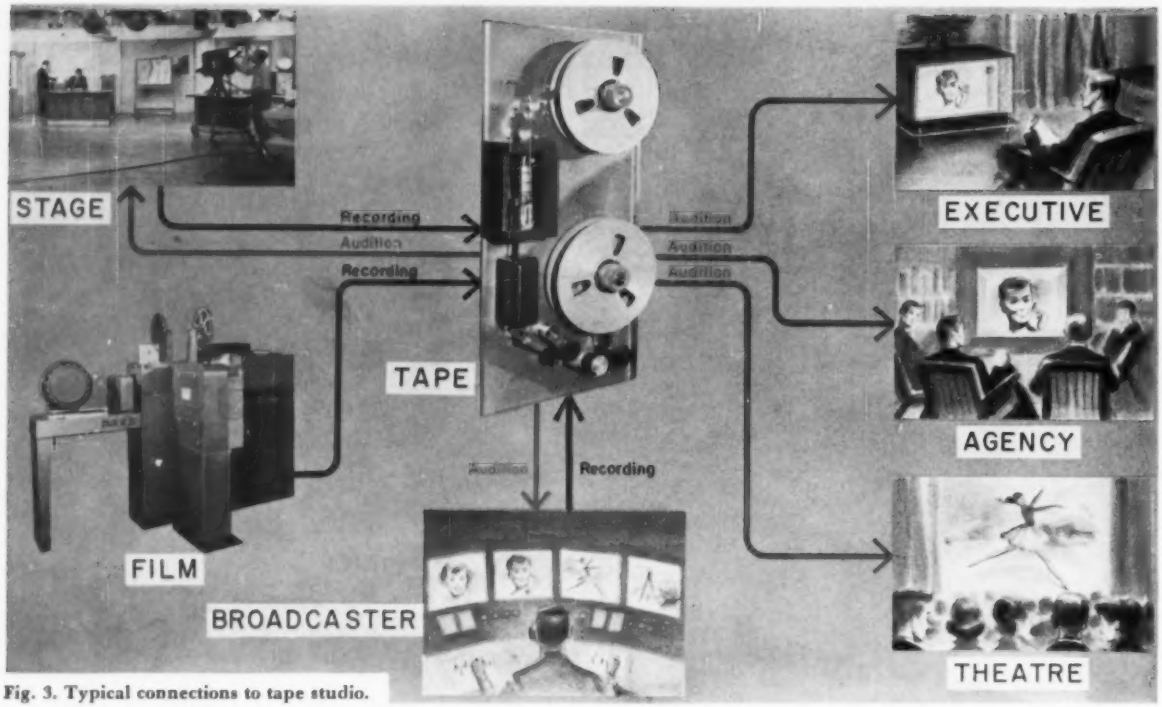

Fig. 3. Typical connections to tape studio.

The local channels provided by the telephone company are designed for broadcasting quality with thousands of miles of network. Consequently, these local channels meet fully the technical requirements for interconnecting videotape locations with either color or monochrome operation.

Typical Uses

Figure 3 illustrates typical video connections between a tape studio and off-premise points. A production stage, a film location and a broadcaster's master control are indicated along with some possible viewing points. The production stage requires one or more lines to the tape-recording center. Inasmuch as the facilities are capable of transmitting in one direction only, a separate line is indicated in the reverse direction for audition and cuing purposes. One line is shown from the film chain location to the tape studio, but here again the actual number and arrangement of circuits depends on the use intended.

A broadcaster may want the material taped to originate from his network, from one of his local studios or from some outside pickup point. Subsequently, the broadcaster may wish to audition the finished tape. Typical viewing channels are suggested to an executive office, an advertising agency and a motion-picture theater. Many such arrangements are possible.

A2A Video System

The shielded cable pairs with associated equipment form a transmission system called A2A,† shown pictorially in Fig. 4. Amplifiers are necessary to make up the losses in the cable; these are placed at the sending studio, the receiving studio and in telephone buildings as required along the line. A2A is designed to connect points up to 10 miles apart.

It is characteristic of transmission by cable that the higher electrical frequencies are attenuated more than the low frequencies. This characteristic of the cable is compensated fully by equalizers installed with the amplifiers and adjusted for the length of line. In the A2A system amplitude-frequency response is adjusted flat across the entire 4-mc video bandwidth to a very close tolerance (0.1 db). Another function of the cable equalizers is to correct for phase delay in the system. No adjustment is required on the part of the user who merely connects to a coaxial jack at each end. A 1-v composite video signal fed at the sending studio produces a corresponding and equal signal at the receiving studio with standard 75-ohm terminations.

An idea of the space required for A2A equipment may be obtained from Fig. 5 which shows a typical group of terminals installed at a studio location. The racks

† R. W. Gast, "Field experience with the A2A Video System," *Elec. Eng. 76:* 44–49, Jan. 1957.

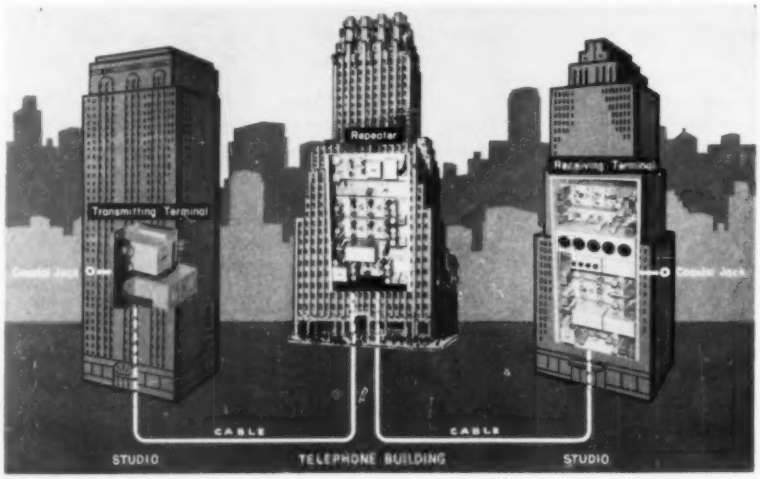

Fig. 4. Local A2A Channel.

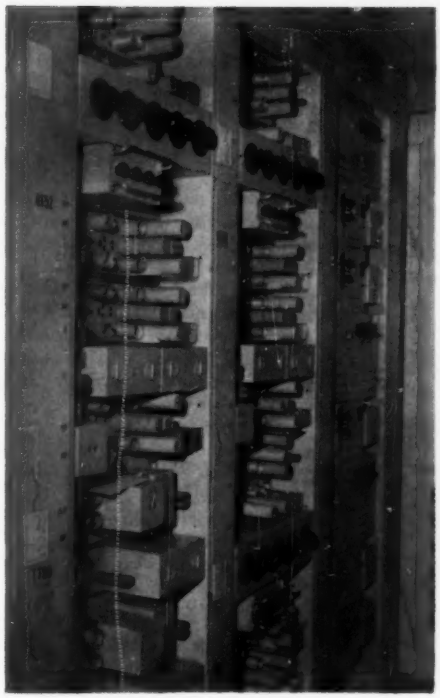

Fig. 5. A2A Equipment bays.

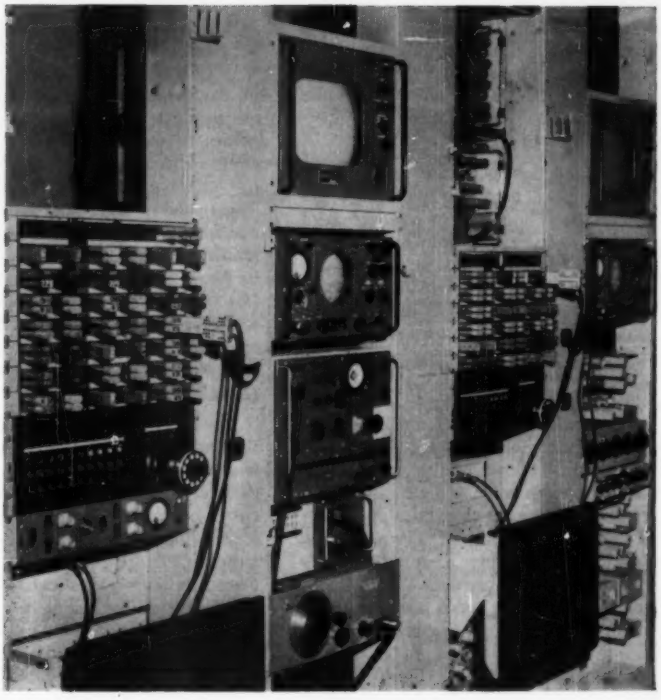

Fig. 6. Test positions and jack fields at a large installation.

are 7 ft high with 19-in. equipment panels. Such an installation accommodates six lines, three incoming and three outgoing. Transmitting terminals can be mounted six per bay and receiving terminals, two per bay. The power supplies occupy the third bay. Where only one or two lines are needed similar equipment may be provided in smaller cabinets. At the tape center, there may be enough lines to warrant special test positions similar to those in Fig. 6.

These facilities should be located within 100 or 200 ft of the studio control room, to which they are connected by means of flexible coaxial cables. Working space is needed on both sides of the rack including enough room to set up portable testing equipment. Figure 7 shows the array of test gear comprising signal generators, precision meters, monitor and oscilloscope; also sets for checking transmission of color information. Space for telephone company facilities should be discussed in the early stages of planning. When an existing studio is being remodeled considerable ingenuity may be called for to arrange a suitable and adequate location.

Substantial construction is often in-

Fig. 7. Testing equipment for local video channels.

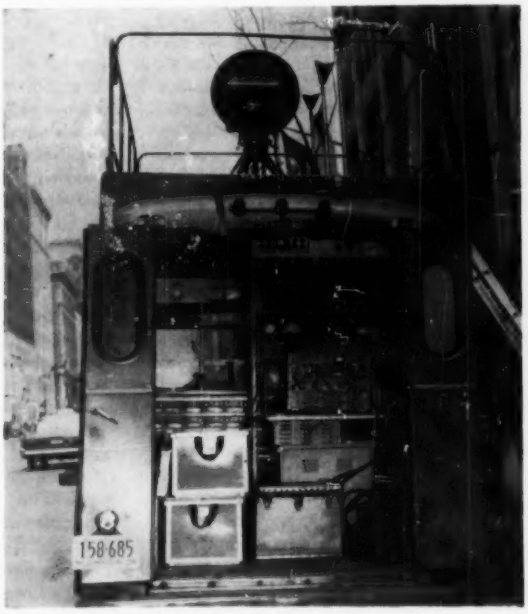

Fig. 8. Microwave truck.

volved in placing the initial cable in a building and installing the terminal equipment. However, once these facilities are in place it becomes relatively simple to rearrange individual lines.

Temporary and Occasional Service

In connection with the provision of video channels there are two basic types of requests. These are for connection of circuits which will remain in operation for extended periods of time and circuits which are temporary. Obviously it may not be practical to install the elaborate facilities just described for a single day's use; also it would not be possible in many cases to meet a close service date. Some other arrangement is needed to supply temporary service, and for this purpose microwave radio equipment is often useful. Figure 8 shows one of the familiar parabolic microwave antennas operating on the roof of a specially equipped telephone truck. Basically, a microwave link consists of a highly directional radio transmitter and receiver. The radio waves are focused into a narrow beam, which travels in a straight line and requires a clear line of sight between the sending and receiving ends.

Within the confines of a city, use of microwave is somewhat restricted due to obstructions lying in the air path, difficulties in securing permission to place equipment on buildings and a limit to the number of clear radio channels. The telephone company has established microwave terminals on high vantage points such as the Empire State Building in New York and Mount Wilson near Los Angeles, facilitating the use of microwave for temporary service. Many of the remote pickups for the broadcasting companies are established in this manner.

Costs

The Bell System companies in the continental United States offer standard local channels for video transmission in connection with television viewers on either a monthly basis or an occasional service basis. Rates are based on a monthly charge plus a mileage charge. Construction charges can apply under certain conditions which must be determined in each specific case.

Summation

The interconnection of studios for video-tape recording is accomplished with wideband channels similar to those furnished to broadcasters and closed-circuit users. The art has progressed to a point where pictures can be transmitted for thousands of miles, when local and intercity facilities are combined.

Substantial networks of special local video cables have been built up, especially in New York and Los Angeles. These can be extended to serve the needs of additional users. The cable facilities are supplemented with portable microwave systems to care for temporary and occasional demands for service.

New service locations require specific planning and in many instances they involve substantial construction work. The telephone company wishes to be of the greatest possible assistance, and to this end telephone people should be consulted in the early stages of planning. Thus the interconnecting channels can be tailored and installed according to individual needs.

Gamma Radiation Insensitive Television Camera Lenses

By JOHN D. HAYES

Vidicon and image-orthicon types of television camera lenses have been designed to utilize only those "non-browning" optical glasses especially developed to maintain their transparency in gamma-radiation fields. The optical and mechanical characteristics of these lenses as well as the performance test data are described.

THE GREATLY accelerated nuclear development programs of the past decade have presented many critical problems to the scientific profession. The optical industry has not been disassociated from the uniqueness of these developments, particularly those relating to the observation and recording of activity within fields of radiation.

Numerous specially designed periscopic-type viewing systems have been fabricated to permit observation through the massive barriers required for the shielding of radiation fields. In addition to these specialized optical viewing systems, remotely operated television cameras located within the radiation area also permit observation of the activity in these hot chambers.

Although the use of periscopic-type observation systems or remotely operated TV cameras is not unusual or particularly unique, their application to areas of gamma radiation presents special problems. Not the least of the problems associated with such observations is the fact that all types of optical glass become colored when exposed to such radiations. The degree of coloration varies from glass to glass; however, it may in general be said that all types of glass color to such an extent that they are rendered virtually useless as windows or optical elements when exposed to gamma radiation of the order of about 10^5 roentgens.[1]

This dosage of 100,000 roentgens is well above the 500- to 600-roentgen range lethal to mankind, yet below the 10^6 (1,000,000) roentgens used in food sterilization work. From a practical standpoint 10^{10} roentgen radiation is about the maximum that has been produced to date.

The coloration of glass exposed to such radiation is of a temporary nature and will fade upon removal of the optic from the field of radiant energy. Acceleration of this bleaching action is induced by the application of heat or exposure of the affected element to either ultraviolet or visible light. However, such a bleaching process can hardly be considered a feasible working solution to the problem of the coloration of optical glass. The need for a practical solution prompted the development in 1954[2] by Bausch & Lomb of a series of five optical glasses insensitive to gamma radiation (Table I). These cerium-bearing glasses maintain their transparency and usefulness up to about 10^9 roentgens cobalt-60 gamma radiation as indicated by recent tests. The greatest coloration found at this field was with the 649338 glass.

Inasmuch as the cerium introduced to prevent coloration induced by gamma radiation also creates a coloration of the

Table I. Bausch & Lomb Radiation-Insensitive Optical Glasses.

Designation	η_D	v
517645	1.5170	64.5
541599	1.5410	59.9
573574	1.5730	57.4
617366	1.6170	36.6
649338	1.6490	33.8

Presented on May 8, 1959, at the Society's Convention in Miami Beach by John D. Hayes, Bausch & Lomb Optical Co., Rochester 2, N. Y. (This paper was received on August 3, 1959.)

glass, a delicate balance of ingredients must be maintained. In either instance the coloration is yellowish, resulting in the absorption of the blue region of the spectrum. As is indicated from the typical data presented in Table II, some sacrifice in the transmission of these glasses is necessary in order to achieve this high degree of protection, compared with the transmission of similar unprotected glasses not subjected to radiation. However, it is also evident that when exposed to 10^6 roentgens gamma radiation these new glasses represent a significant improvement in transmission.

In a typical remote television installation for the observation of a reactor, three items of glass have a profound effect upon the results, namely, the lights used for illumination, the television camera lenses and the camera pickup tube. Rapid and substantial coloration of the lights may be expected because of the use in their manufacture of heat-resistant glass which is extremely sensitive to radiation. The camera lenses and pickup tube may also be expected to suffer coloration and loss of transmission. Inasmuch as the pickup tube face is relatively thin in comparison with the other optics, it will in general exhibit the least coloration and have the minimum loss of transmission. However, since it is not uncommon for remote TV equipment to be rendered useless because of the magnitude of these transmission losses, it is necessary that ways and means be found to effectively reduce these losses due to coloration.

It is in this connection that a series of lenses has been developed for use on vidicon- and orthicon-type cameras. These lenses utilize optical elements made of only the non-browning glasses. This series of six lenses, Table III, for television cameras ranges in focal length from 18mm to 152mm and from $f/2.5$ to $f/4$. This series thus extends from wide angle to telephoto and is of sufficient speed to permit the remote viewing of most installations without resort to excessive illumination levels.

The importance of a series of lenses in lieu of a single lens for these reactor applications can be appreciated upon consideration of the field coverage of the various lenses. For example, at a distance of 10 ft the image reduction on the tube face varies from 168 times for the 18mm lens to 19 times for the 152mm lens. The field coverage of the various lenses varies

Table II. Transmission of Protected and Unprotected Glasses; Thickness, 1 cm.

	Zero Radiation, %			10^6 Roentgen Radiation, %	
λ (mμ)	Unprotected	Protected	Glass	Unprotected	Protected
400	91.5	82.0	517645	.0	64.0
500	91.5	90.5	"	9.5	86.5
600	91.8	91.5	"	35.0	88.5
400	90.0	77.0	541599	.0	67.0
500	90.8	90.5	"	13.0	88.8
600	91.0	91.0	"	36.8	89.8
400	86.0	20.0	617366	.0	8.0
500	89.0	86.0	"	.0	83.5
600	89.5	88.7	"	0.5	87.5
400	78.5	12.0	649338	.0	1.0
500	87.9	85.4	"	1.6	75.3
600	88.6	88.0	"	17.0	84.1

Table III. Radiation-Insensitive Lenses for Vidicon-Type Cameras.

Focal Length, mm	f/No.	Total Angular Coverage Horiz.	Vert.	Diag.
18	2.5	39.3°	30.0°	48.7°
25	2.5	28.0°	21.3°	34.5°
50	2.5	14.3°	10.8°	17.3°
75	2.5	9.5°	7.3°	11.0°
100	3.5	7.3°	5.3°	9.0°
152	4.0	4.7°	3.6°	5.5°

Based upon format size of 0.500 in. by 0.375 in.

at this same object distance from an area 84 in. by 63 in. for the 18mm lens down to one of about $9\frac{1}{2}$ in. by $7\frac{1}{8}$ in. for the 152mm lens.

The lens type found most adaptable to the use of the non-browning glasses was of the well-known and highly suitable split-front triplet construction (Fig. 1), classified K-a by Kingslake. This generalized design has been utilized for all of the lenses except the 18mm. Its construction is ideally suited to this application both because of the feasibility of incorporation of the desired glasses into the design and because of the moderate speeds required and relatively small angular coverage needed. A highly satisfactory aberrational correction has been achieved in the design of all of these lenses and their use has resulted in excellent performance.

For the 18mm wide-angle lens, the reversed telephoto-type, T-d of the Kingslake classification, was chosen (Fig. 2). This lens essentially consists of the split-front rear with an afocal wide-angle attachment type of front. Such a combination when designed as an integrated unit is characterized by a high degree of illumination, good residual correction and "long" back focal length. The latter consideration is important when turret camera operations are necessary. The minimum back focal distance of this lens is 0.630 in., whereas that of the 25mm lens is only 0.600 in. However, both distances are well in excess of the 0.530-in. minimum that can be accommodated on a C-mount type of camera.

The high degree of correction obtained from these designs is illustrated by representative data obtained from tests upon electronic evaluation equipment similar to that described before the Society in 1955 by Hutto.[3] As discussed last year,[4] this type of equipment consists of a rotary scanning drum target, a photomultiplier pickup and an oscilloscope. The square-wave flux pattern target is imaged by the lens under test. This aerial image is magnified by a microscope of suitable power, analyzed by the photomultiplier and presented on the oscilloscope as an average square-wave response vs. line number.

Figure 3 represents the test data obtained from the 18mm lens. An excellent average square-wave response has been obtained out to and beyond the reproduction capabilities of the present-day vidicon tubes. Even the full field-performance test data are indicative of a most favorable performance level.

Despite the fact that the tube face has been considered in the design of these lenses, the overall performance level is generally slightly less in the tangential direction than in the sagittal because, as Cook[5] has pointed out, the aberrations introduced by the tube face are most severe in the tangential direction. For this reason the data presented are based upon the tangential response curves.

Figure 4 presents the same type of data for the 75mm lens. This lens, the 100mm and the 152mm lenses will, if suitably mounted, yield a highly satisfactory performance on the image-orthicon format as well as the smaller vidicon format. This is evidenced by the response curve shown here at the angle of 15°, which is the half-angular coverage of this lens on the orthicon tube.

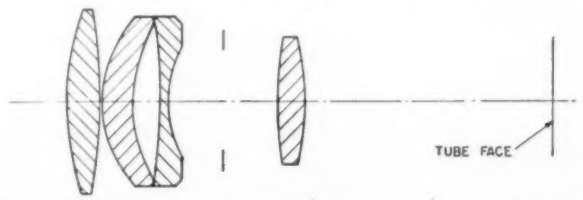

Fig. 1. Basic form of the 25mm, 50mm, 75mm, 100mm and 152mm lenses.

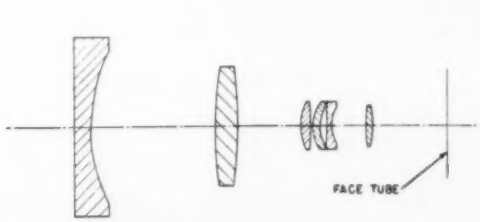

Fig. 2. Basic form of the 18mm lens.

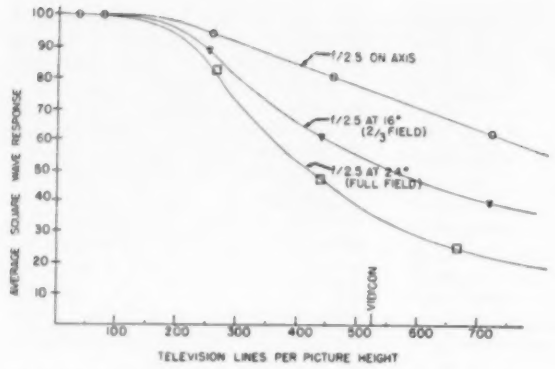

Fig. 3. Performance characteristics of the 18mm *f*/2.5 lens.

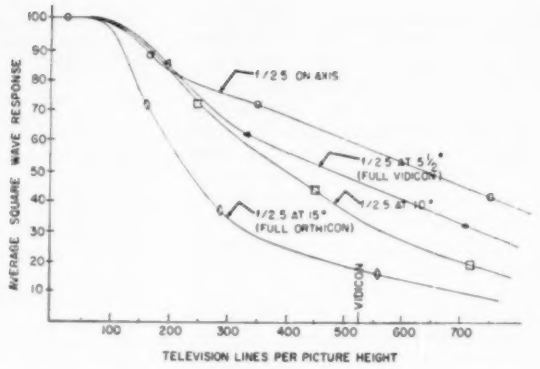

Fig. 4. Performance characteristics of the 75mm *f*/3.5 lens.

The 100mm lens is optically identical with the 100mm *f*/3.5 lens introduced in the standard vidicon-type camera series in 1958.[4] It is to be noted that the 75mm lens described in that series is also of the split-front type and utilizes similar types of glasses in its design; however, because of the aforementioned transmission losses of the protected glasses, the standard vidicon-type lenses are not made of these protected glasses; and the radiation-protected lenses are not made of non-protected variety of these glasses.

Figure 5 shows the protected lenses as mounted for vidicon-type cameras. All of these lenses are mounted in fixed-focus-type C-mounts. With the exception of the diaphragm leaves, all of the mechanical parts are of a special aluminum alloy selected because of its freedom from long half-life elements. In this connection it approaches pure aluminum and its machinability and finishing qualities are favorable for manufacture.

All of the lenses may be stopped down by a clockwise rotation of the iris control ring, thus simplifying their installation onto remotely operated cameras. Because of the excessive drag created by click-stops requiring high torque actuation equipment these lenses are normally provided without click-stops. Each lens stops from its maximum aperture to *f*/22.

The lens elements are well recessed into the lens mounts, thus good light-shielding is provided to prevent the exposure of the pickup tube to stray illumination. Additionally, the lens elements are anti-reflection-coated to a "straw color" which represents a film thickness appropriate to the maximum transmission of the light in the spectral sensitivity region of the commonly used pickup tube phosphors; namely, the blue-green.

The three lenses exchangeable on orthicon cameras, the 75mm, 100mm and 152mm, are mounted for adaptation to the orthicon camera in either fixed-focus or focusing mount, as required.

With the variety of possible adaptations of these radiation-protected lenses, it may be said that six fixed-focus lenses and three focusing-mount lenses are available for the vidicon-type cameras; also, three fixed-focus and three focusing-mount lenses are available for the orthicon camera.

Fig. 5. Lenses as mounted for vidicon-type cameras. Top, left to right: 75mm *f*/2.5, 100mm *f*/3.5, 152mm *f*/4. Bottom, left to right: 18mm *f*/2.5, 25mm *f*/2.5, 50mm *f*/2.5.

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Unified Analysis of Depths of Field and Focus

By DANIEL LEVINE

The depths of field and of focus contribute independently to the size of the circle of confusion in the viewing plane. An integrated analysis permits treating both a three-dimensional object space and a film surface that does not conform to the curvature of the image field, or is not smooth. The investigation is restricted to a symmetric lens in order to avoid complications concerning the size and location of entrance and exit pupils. In a design problem the following quantities are assumed to be specified: (1) the depths of field and of focus, as defined by the nature of the object surface and tolerances in the film plane; (2) the overall magnification between the object and the ultimate image for viewing purposes, as well as the acceptable size of the circle of confusion in the final viewing plane; and (3) the aperture setting, as indicated by the conditions of exposure. For these conditions the camera magnification is uniquely determined — provided that the f/number exceeds a value of $m(D_o + dp')/2c''$. In this equation m is the overall magnification, D_o is the depth of the object field, dp' is the accuracy of the lens setting, and c'' is the size of the circle of confusion in the viewing plane. In the development, it is assumed that all effects are additive in enlarging the circle of confusion, and also occur at their maximum magnitudes. As a consequence, the worst possible case is analyzed, so that the design is handled conservatively.

IN MANY INSTALLATIONS for photography of a cathode-ray tube, the camera body is in a rigid assembly which effectively prevents any change of position of the film plane with respect to a fixed coordinate system. The total path length may be varied by sliding the tube along the optical axis, and in the better equipments the lens can be focused. Pertinent design factors that are described in this paper are the following: (a) precision of locating the faceplate for a specified tolerance on the image magnification; (b) tilt of the faceplate with respect to the optical axis; (c) tolerance on lens position; and (d) depth of focus.

Path Length

For photography of a cathode-ray tube, the total path length[1] depends upon the means of locating the face of the tube, and often varies slightly when tubes are changed. As a consequence, it then is necessary to refocus the camera. For a camera magnification m_c the optical path length* L is

$$L = (2 + m_c + \frac{1}{m_c})L_f \qquad (1)$$

where L_f is the focal length of the lens. The change of path length with magnification is, therefore,

$$dL = \frac{L_f(m_c^2 - 1)}{m_c^2}\, dm_c \qquad (2)$$

so that the relative change is given by

$$\frac{dL}{L} = \frac{m_c - 1}{m_c + 1}\left(\frac{dm_c}{m_c}\right) \qquad (3)$$

The positioning tolerances for the cathode-ray tube are determined by the specification of the magnification and its allowable limits, in accord with Eq. (3). This equation is evaluated in Table I for selected magnifications, and a 1% change in magnification $(dm_c)/m_c$.

According to either Eq. (2) or (3), or the table, the path length cannot change in absolute value at unit magnification. This result is not unexpected, as the total path length cannot decrease below $4L_f$ in a camera — a distance required for unit magnification. To obtain the tolerance on total path length for this case, it is best to solve Eq. (1) directly for the distances at the extremes of permissible magnification and then subtract from $4L_f$.

For a magnification of 0.2, Table I shows that a 150mm lens has a path tolerance of almost 7.2 mm, while the same lens at a magnification of 2 results in a tolerance of only 2.25 mm. These numbers apply for a permissible change of 1% in the respective magnifications. It should be noted that the tolerance decreases from 7.2 mm at $m_c = 0.2$ to zero at unit magnification, and then starts to increase until it is 2.25 mm at a magnification of 2. It obviously is undesirable to work very close to unit magnification.

Alternatively, the relative positional change $|dL/L|$ may be prescribed by the flexibility desired for interchanging cathode-ray tubes or for variation in the thickness of the faceplate. For either of these conditions the relative change of magnification from the nominal value may be obtained by solving for dm_c/m_c in Eq. (2). Of course it is essential that the resulting value of dm_c/m_c be suitable for the application.

In conclusion, we see that the positional accuracy of the phosphor (object surface) is determined by the magnification and its acceptable deviation. The next problem concerns the location and tilt of the phosphor surface, as well as the accuracy of focusing. To introduce this topic, we shall consider the circle of confusion in the final viewing plane.

Circle of Confusion

The circle of confusion in the print or in the projection of a positive transparency, or indeed in the original negative if this should be used directly, should subtend such a small angle at the viewer's eye that it appears to be a point.[2-5] If the negative is to be used in a flying-spot scanner, then a different criterion has to be applied, depending on the characteristics of the equipment.

The diameter of the circle of confusion in the image having the form in which the photograph is finally viewed by eye or other instrumentation is denoted by c''. For visual observation we shall assume that the standards of critical photography apply to a cathode-ray tube image, and require that the final picture have a circle of confusion at the eye of the viewer equal to 0.03 degree (1/1700 radian). It may turn out that the spot size of the tube in the final image is larger than the diameter of the circle of confusion. If this occurs, it should not be construed as indicating too demanding a figure on the circle of confusion, but

Table I. Change of Path Length for 1% Change in Magnification.

m_c	0.01	0.02	0.1	0.2	1	2
$\left\|\frac{dL}{L}\right\|$	0.98%	0.96%	0.82%	0.67%	0.00	0.33%
$\left\|\frac{dL}{L_f}\right\|$	1	0.5	0.099	0.048	0.000	0.015

A contribution first received on June 20, 1959, and in final form on August 10, 1959, from Daniel Levine, Consulting Engineer, 3826 North 55th Drive, Glendale, Ariz.

* The optical path length differs from the mechanical path length by the separation of the principal planes. The magnification is taken to be positive, as are all distances. The standard optical conventions of sign which are violated by these definitions would introduce excessive manipulative difficulties in a treatment of depths of field and focus.

rather as showing that the focusing system is not degrading the image excessively. In any event, it would be a mistake to put any great amount of reliance on the result, as there is a significant difference between the viewing requirements for an ordinary scene and a cathode-ray tube image. Until more specific information is available, however, it is deemed best to err on the conservative side.

For a normal viewing distance of 0.3 m, the angle selected provides a circle having a diameter of 0.175 mm. For example, if a positive print is made with a magnification of 20, the circle of confusion in the negative has a diameter c'_e of 8.75 microns. If the image on the negative is made with a camera magnification of 0.2, the circle of confusion has a diameter of 43.8μ in the object plane, provided that the lens and film do not also contribute to its size. The complications introduced when the latter assumption is not valid are developed in a later section.

Depth of Field

The depth of field is the distance along the optical axis in the object space over which the quality of focus is acceptable for given conditions of observation. In Fig. 1(a) the ray that just passes through the entrance pupil from the far limit of the field crosses the optical axis in front of the image plane. All rays from the far field-point that pass through the lens lie within a cone that produces a circle of confusion of diameter c' in the image plane. The disk in the object plane of diameter

$$c = \frac{c'}{m} \tag{4}$$

is conjugate to this particular image.

If a ray originates at each point where the bounding cone passes through the nominal object plane of Fig. 1(a) and has the same direction as the corresponding element in the cone, it will follow the same path to the image plane. Since the bounding cone cuts the object plane in a circle which is then imaged as a circle of radius c', it follows that this circle is identical to the conjugate circle in the object plane of diameter c. Consequently, it is immaterial whether one analyzes the depth of field in terms of either the ray diagram of Fig. 1(a) or the disk conjugate to the circle of confusion in Fig. 1(b). In the latter diagram it is readily seen that

$$\frac{D_f}{\frac{c}{2}} = \frac{p}{\rho - \frac{c}{2}}$$

where the nominal object plane is a distance p from the entrance pupil, which has a radius ρ. The distance from the object plane to the far field-point is D_f. Rearrangement of this equation yields

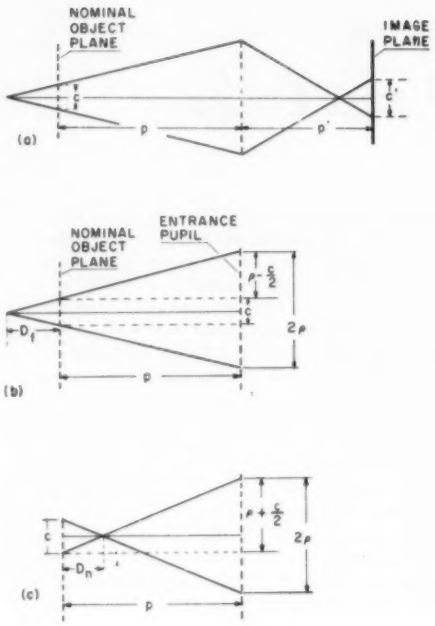

Fig. 1. Depth of field.

$$D_f = \frac{cp}{2\rho - c} \tag{5}$$

Figure 1(c) is employed in a similar manner to show that the distance between the object plane and the near field-point is

$$D_n = \frac{cp}{2\rho + c} \tag{6}$$

The total depth of field† D is, therefore,

$$D = D_n + D_f$$
$$= \frac{4\rho cp}{4\rho^2 - c^2} = \frac{cp}{\rho}\left(\frac{1}{1 - \frac{c^2}{4\rho^2}}\right)$$
$$= \frac{cp}{\rho}\left(1 + \frac{c^2}{4\rho^2} + \frac{c^4}{16\rho^4} + \cdots\right) \qquad c < 2\rho \tag{7}$$

In this paper we shall be concerned with the condition $c^2 \lll 4\rho^2$; this limitation is reasonable for cathode-ray tube photography, as the circle of confusion in the object space should not exceed the spot size of the electron beam, and this is much less than the lens aperture in any practical application. Then

$$d \doteq \frac{cp}{\rho} \tag{8}$$

The entrance and exit pupils of a symmetrical lens lie in the principal planes,‡ so that for this type of lens, or for a simple lens, the distance between entrance pupil and object plane is

$$p = L_f \frac{(m_e + 1)}{m_e} \tag{9}$$

Furthermore,

$$\rho = \frac{L_f}{2f_N} \tag{10}$$

where f_N is the f/number. Consequently, the depth of field for a symmetrical lens may be written as

$$D \doteq \frac{2cf_N(1 + m_e)}{m_e} \tag{11}$$

For photography of a cathode-ray tube, the physical factors that determine the depth of field required for an installation are (a) the curvature of the faceplate, and its tilt relative to the optical axis; (b) uncertainty of the position at which the faceplate is intersected by the optical axis; and (c) error in the distance scale or in the lens focal length, or equivalent error in the focusing process.§ Our interest is in the worst conditions, so that we shall assume that the distance errors under (b) and (c) are not compensatory. The first two

† The different expressions for depth of field employed in this paper are selected for their pertinence to our specific problem. Many alternative relations are to be found in the literature, as may be noted in the references. The series expansion in Eq. (7) is valid only when the circle of confusion in the object space is smaller than the lens aperture. When this condition is violated, the depth of the far field, Eq. (5), is negative, which serves to indicate that the circle of confusion for the far field is in reality smaller than the permissible value. If desired, the photographer may then focus on a closer point, so that the circle of confusion approaches the acceptable diameter at the far field-point (i.e., at infinity). The range at which this occurs is the hyperfocal distance; thus, the hyperfocal distance may be defined as the distance to the nominal object plane in which the conjugate of the circle of confusion has a diameter equal to that of the lens aperture. When the lens is focused for this distance, the circle of confusion approaches its acceptable value for points toward the horizon.

‡ Ref. 5, p. 73.

§ Several factors that may contribute to errors of the third type are described in Ref. 1.

elements may be combined into the depth of the object surface D_o while the third constitutes an additional term which we may denote by dL. When the focal length is correct, the equation for the image distance is

$$p' = (1 + m_c)L_f$$

whence

$$dp' = L_f dm_c \tag{12}$$

which may be substituted into Eq. (2) to obtain an alternative expression for dL,

$$dL = \frac{m_c^2 - 1}{m_c^2}\, dp \tag{13}$$

In this equation dL is the change of distance between object and image planes caused by an error in lens setting dp'. When the camera magnification is less than one in absolute value, Eq. (13) shows that a decrease in the lens-to-image distance p' increases the total path, since the righthand side is the product of two negative factors. With the relation for the change of path length because of erroneous positioning of the lens, the total depth of field required for the worst case may be expressed as

$$D = D_o + |dL| = D_o + \left|1 - \frac{1}{m_c^2}\right| |dp'| \tag{14}$$

Equations (11) and (14) are different forms of expression for the same quantity. The latter depends upon tolerances within the optical system, while the former is a function of the optical parameters.

Definition of k

In optical theory, the depth of focus is the maximum permissible displacement of the film from the plane of true focus when the object lies in a plane perpendicular to the lens axis.[‖] In photographic practice, however, it often is defined as the image space conjugate to the limits on the depth of field.[¶] Neither of these definitions is pertinent to the present problem where both object and emulsion have dimensions in depth because of tilt, buckling and curvature. Furthermore, no part of the object and emulsion surfaces need be in conjugate planes.

In the image plane, the circle of confusion has a diameter $c' = m_c\, c$ *provided that the emulsion lies in a perfect plane*. When this is not the case, there are at least four different circles of confusion in the optical system:

(1) The equivalent disk in the nominal object plane of diameter c

(2) The image of this disk in a perfect image plane,

$$c' = m_c\, c \tag{15}$$

(3) The larger circle of confusion c'_e in the real emulsion resulting from tilt or warpage of the image plane or curvature of image field,

$$c'_e = kc' \tag{16}$$

(4) The circle of confusion in the final form that the photograph is applied,

$$c'' = m_e c'_e \tag{17}$$

where m_e is the magnification between the negative and the final image. Thus, if a positive print is prepared, m_e is the enlargement of the negative. Or if the image is projected onto a screen, m_e is the magnification of the image on the viewing surface.** This diameter c'' is the critical one for the observer, as described in an earlier section.

Since

$$c'' = m_e c'_e = m_e k c' = m_c m_e k c \tag{18}$$

the depth of field may be expressed as

$$D \doteq \frac{2c'' f_N (1 + m_c)}{m_c^2 m_e k} \tag{19}$$

The overall magnification

$$m = m_c m_e \tag{20}$$

permits writing this equation in the alternative form

$$D \doteq \frac{2c'' f_N}{mk}\left(\frac{1 + m_c}{m_c}\right) \tag{21}$$

Although Eq. (21) has been derived for a symmetrical lens, it is a good approximation for all but very unsymmetrical lenses when the magnification is greater than perhaps 0.5. Since a symmetrical lens is often used when the magnification is near unity, the practical limitation is most likely to arise in macrophotography with an unsymmetrical lens.

Depth of Focus

The significance of the quantity k is developed by means of the sketch of Fig. 2(a), which shows the nominal film plane at p' and the image of the near field-point at p'_n. Actually the film emulsion may be at p'_{ne}, so that the circle of confusion is increased in diameter, and

$$\frac{p'_n - p'}{c'} = \frac{p' - p'_{ne}}{c'_e - c'} \equiv \frac{p' - p'_{ne}}{c'(k - 1)}$$

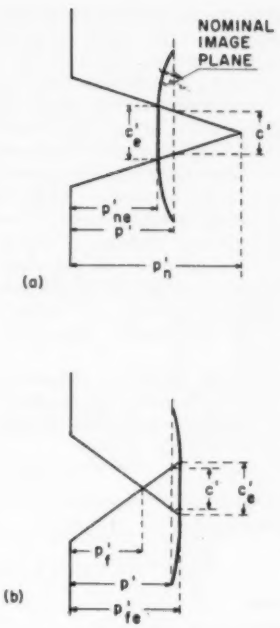

Fig. 2. Depth of focus.

or

$$p' - p'_{ne} = (k - 1)(p'_n - p') = (k - 1)D'_n \tag{22}$$

where D'_n is the image space which is conjugate to the object space of D_n in Fig. 1(c). Thus, for $k = 2$, the emulsion is as far in front of the nominal image plane (in some places) as the near field-point conjugate is beyond this plane.

When the positional deviation of the emulsion is in the opposite direction, the circle of confusion of the far field-point is increased, as illustrated in Fig. 2(b). Now

$$\frac{p' - p'_f}{c'} = \frac{p'_{fe} - p'}{c'_e - c'} \equiv \frac{p'_{fe} - p'}{c'(k - 1)}$$

and

$$p'_{fe} - p' = (k - 1)(p' - p'_f) = (k - 1)D'_f \tag{23}$$

where p'_f is the image point conjugate to the far field-point, and D'_f is the image space which is conjugate to D_f in Fig. 1(b). When k is equal to 2, the emulsion is as far beyond the nominal image plane (in some places) as the far field-point conjugate is in front of it.

In general, when the near and far field-points are specified, the depth of focus D'_F is

$$D'_F \equiv p'_{fe} - p'_{ne} = (k - 1)(p'_n - p'_f) = (k - 1)D' \tag{24}$$

where D' is the region of the image space which is conjugate to the depth of field D.

The depth of focus is equal to the distance between conjugate near and far field-points when the circle of confusion on the emulsion is twice as large as its

[‖] Ref. 5, pp. 77–79.
[¶] Ref. 3, p. 7, and Ref. 2, p. 85.

** In relating c'' and c'_e only by the magnification of the enlargement process, we are assuming that no degradation in quality occurs after formation of the initial image. In ordinary motion-picture projection this is far from the true state, as described by Borberg in Ref. 6. The additional generality required for such systems is obtained by writing Eq. (17) as $c'' = k_e m_e c'_e$, where $k_e > 1$. As the interpretation of k_e is similar to that of k, its omission here permits of a simplified presentation. Furthermore, each application with different means of utilizing the initial negative requires its own set of k's, so that inclusion of k_e would not cover all possibilities. Since any specific illustration constitutes a routine extension of the problem with only one k-value, there is no difficulty in analyzing other cases.

value in the nominal image plane. The extent of the focal region in the image space, even for this case, does not correspond exactly with the image of the object space associated with the depth of field, as may be noted in Fig. 2. Furthermore, the region of acceptable focus extends farther toward the lens than away from it, as may also be observed in the figure. While this is correctly stated, it may be noted that the sketches of Fig. 2 are greatly exaggerated. In the Appendix it is shown that the ratio of the near and far regions of the depth of focus differs but little from unity [Eqs. (43) and (44)].

To a high degree of approximation, the relation between the depth of field and its conjugate in the image space is

$$D' = m_c^2 D \tag{25}$$

as derived in the Appendix, Eq. (46). Substitution into Eq. (24) yields

$$D'_F = m_c^2(k-1)D \tag{26}$$

whence

$$k = 1 + \frac{D'_F}{m_c^2 D} \tag{27}$$

The explicit expression for k in Eq. (27) is more useful than the defining relation of Eq. (16) when the depths of field and of focus are determined by the application. For completeness, we may indicate the expression for the depth of focus of a symmetrical lens, obtained by eliminating D between Eqs. (21) and (26):

$$D'_F = \frac{2(k-1)}{mk} c'' f_N m_c (1 + m_c) \tag{28}$$

The utility and limitations of these relations are best developed by means of several examples.

Example 1

A flat-face cathode-ray tube is tilted one-quarter degree relative to the optical axis. For a sweep length of 0.1 m (about 4 in.), therefore, the far and near points of its surface are displaced 0.44 mm. The two surfaces of the faceplate are almost parallel, contributing less than 0.1 mm to the required depth of field. Finally, the point of intersection of the optical axis with the center of the tube face is fixed within 0.30 mm. The sum of these three quantities is equal to the depth of field required for the object surface; hence,

$$D_o = 0.84 \text{ mm}$$

The distance scale on the symmetrical lens is calibrated†† so as to position it within 25μ (about one thousandth of an inch), so that the total depth of field, Eq. (14), is

$$D = 0.84 + 0.025 \left| 1 - \frac{1}{m_c^3} \right|$$

For $k = 2$, $m = 3$ and $c'' = 0.175$ mm, Eqs. (26) and (21) lead to

$$\left.\begin{aligned} D'_F &= m_c^2 D \\ f_N &= 17.2 D \frac{m_c}{1 + m_c} \end{aligned}\right\} \tag{29}$$

Table II shows the dependence of the aperture and depths of field on the camera magnification for this case. The specification of a fixed value for k leads to a depth of focus that increases rapidly with the magnification. In the next illustrative problem, the depth of focus is specified, and k then is a function of the magnification.

Example 2

In the installation described above, the depth of focus to allow for film buckling and curvature of the image field is specified as 1.0 mm,‡‡ while the values of the overall magnification and the circle of confusion in the viewing space are the same; i.e., $m = 3$ and $c'' = 0.175$ mm. Tabulate k and f_N. The k-values in Table III are obtained from Eq. (27) and are related to the contribution of the depth of focus relative to that of the depth of field in producing the overall circle of confusion. Thus, for camera magnification of 0.2 in this problem, the depth of focus provides an increase of 1720%, whereas when the magnification is 2 the increase is only 30%.

The f/number is obtained from Eq. (21) as

$$f_N = \frac{mkD}{2c''} \left(\frac{m_c}{1 + m_c} \right) \tag{30}$$

and is listed in the last column of the table.

As the camera magnification increases to very large values, Eqs. (14), (27) and (30) become

$$D \to D_o + dp' \tag{31}$$

$$k \to 1 \tag{32}$$

and, therefore,

$$f_N \to \frac{m(D_o + dp')}{2c''} \tag{33}$$

In Table III the limiting value for Example 2 is given as $f/5.0$. If the exposure is limited, as in most cathode-ray tube photography, a larger aperture may be required. Then it is necessary to do one or more of the following, based on Eq. (33):

(1) decrease the overall magnification;

(2) decrease the depth of field of the object surface, or decrease the magnitude of the tolerance on lens positioning;

(3) increase the size of the circle of confusion in the viewing field.

More generally, when the aperture setting also is specified, the initial step is to verify that its magnitude exceeds the value of Eq. (33). If not, some parameter must be modified, as outlined above. When this condition is met, then the tabulation can proceed as in Table III, and the correct camera magnification can be determined. The solution is equivalent to a graphical one, since, in effect, we obtain the answer by plotting f_N as a function of the camera magnification. An explicit solution for the camera magnification can be expressed by substituting Eqs. (14) and (27) into (21). This approach is more direct and elegant than the graphical method, but actually it is even more tedious of solution, and therefore it is only mentioned in passing.

Table II. Values for Example 1.

m_c	$\lvert dL \rvert$ (mm)	D (mm)	D'_F, (mm)	f_N
0.2	0.600	1.45	0.06	4.2
0.5	0.075	0.92	0.23	5.3
1	0	0.85	0.85	7.3
2	0.019	0.87	3.45	10.0
3	0.022	0.87	15.56	11.2

Table III. Values for Example 2.

m_c	D	k	f_N
0.2	1.45	18.2	38
0.5	0.92	5.3	14
1	0.85	2.2	8.1
2	0.87	1.3	6.5
3	0.87	1.1	6.2
∞	0.87	1.0	5.0

Summary

The positional accuracy for locating an object plane, such as the phosphor of a cathode-ray tube, is dependent upon the camera magnification and its tolerance, in case these should be critical quantities. This problem is distinct from that of the depth of field, where the emphasis is on preservation of satisfactory detail.

The criterion of satisfactory image quality may be stated as the diameter of the circle of confusion in the final viewing space. Its size is determined by the depth of field in the original object space, the depth of focus of the camera, and the additional degradation in each step of processing, including the projection of the final image. For purposes of illustration only the first two contributions are described in detail, but the treatment is readily generalized for more complicated systems.

In essence, if the depths of field and of focus, as well as the f/number, are specified for an application, then the

†† In practice the focusing generally is accomplished by taking photographs at different lens positions, rather than relying on a distance scale. In effect, we are stating that the focusing procedure permits finding the proper location for the lens with a tolerance of $\pm 25\mu$.

‡‡ A depth of focus of 1.0 mm permits the emulsion to deviate ± 0.5 mm from the focal surface, since the acceptable image space is essentially equidistant either side of the nominal film surface, as described in the Appendix, Eqs. (47) and (44).

camera magnification is uniquely determined, provided that the f/number exceeds the limiting value of Eq. (33). This equation, as well as many of the others, is derived for the condition that the circle of confusion in the object space is very much smaller than the diameter of the entrance pupil of the optical system, as for photography of a cathode-ray tube. The formulas are not valid in their present forms for general photography, where the circle of confusion in the object space may be many times larger than the lens aperture.

APPENDIX

Relation Between Near and Far Distances

(a) Depth of Field

The ratio of Eqs. (5) to (6) is

$$\frac{D_f}{D_n} = \frac{2\rho + c}{2\rho - c} \tag{34}$$

so that for $c < 2\rho$,

$$\frac{D_f}{D_n} = \left(1 + \frac{c}{2\rho}\right)\left[1 + \frac{c}{2\rho} + \left(\frac{c}{2\rho}\right)^2 + \left(\frac{c}{2\rho}\right)^3 + \cdots\right]$$
$$= 1 + \frac{c}{\rho} + \frac{c^2}{2\rho^2} + \cdots \tag{35}$$

and for $c \ll 2\rho$,

$$\frac{D_f}{D_n} \doteq 1 + \frac{c}{\rho} \tag{36}$$

Since the second term is positive, the far field-distance always exceeds the near field-distance.

(b) Conjugate Points to the Depth of Field

In Fig. 1(c) the distance from the entrance pupil to the near field-point is seen to be

$$p_n = p - D_n$$
$$= p - \frac{cp}{2\rho + c} \equiv \frac{2\rho p}{2\rho + c} \tag{37}$$

while in Fig. 1(b) the distance to the far field-point is

$$p_f = p + D_F$$
$$= p + \frac{cp}{2\rho - c} \equiv \frac{2\rho p}{2\rho - c} \tag{38}$$

From the lens equation,

$$p' = \frac{pL_f}{p - L_f} = mp$$

and

$$p'_n = \frac{p_n L_f}{p_n - L_f} = \frac{\dfrac{2\rho p L_f}{2\rho + c}}{\dfrac{2\rho p}{2\rho + c} - L_f}$$
$$\equiv \frac{2\rho p L_f}{2\rho(p - L_f) - cL_f}$$

As

$$p - L_f = \frac{L_f}{m}$$

the last equation reduces to

$$p'_n = \frac{2\rho pm}{2\rho - mc} \equiv \frac{2\rho p'}{2\rho - c'} \tag{39}$$

Similarly,

$$p'_f = \frac{p_f L_f}{p_f - L_f} = \frac{\dfrac{2\rho p L_f}{2\rho - c}}{\dfrac{2\rho p}{2\rho - c} - L_f}$$
$$\equiv \frac{2\rho p L_f}{2\rho(p - L_f) + L_f c}$$
$$= \frac{2\rho pm}{2\rho + mc} = \frac{2\rho p'}{2\rho + c'} \tag{40}$$

Then the ratio of the conjugate near and far distances is

$$\frac{D'_n}{D'_f} \equiv \frac{p'_n - p'}{p' - p'_f} = \frac{\dfrac{2\rho}{2\rho - c'} - 1}{1 - \dfrac{2\rho}{2\rho + c'}}$$
$$\equiv \frac{2\rho + c'}{2\rho - c'} \tag{41}$$

so that, for $c' < 2\rho$,

$$\frac{D'_n}{D'_f} = \left(1 + \frac{c'}{2\rho}\right)\left[1 + \frac{c'}{2\rho} + \left(\frac{c'}{2\rho}\right)^2 + \left(\frac{c'}{2\rho}\right)^3 + \cdots\right]$$
$$= 1 + \frac{c'}{\rho} + \frac{1}{2}\left(\frac{c'}{\rho}\right)^2 + \cdots \tag{42}$$

and for $c' \ll 2\rho$,

$$\frac{D'_n}{D'_f} \doteq 1 + \frac{c'}{\rho} \tag{43}$$

The distance conjugate to the nearer portion of the field always exceeds that conjugate to the farther portion. As the circle of confusion in the nominal image plane ordinarily is only a very small fraction of the radius of the entrance pupil,

$$D'_n \doteq D'_f \tag{44}$$

is a very good approximation.

The difference between p'_n and p'_f represents the region of the image space that is conjugate to the depth of field:

$$D' = p'_n - p'_f$$
$$= 2\rho pm\left(\frac{1}{2\rho - mc} - \frac{1}{2\rho + mc}\right)$$
$$= \frac{4\rho m^2 pc}{4\rho^2 - m^2c^2} = m^2\frac{pc}{\rho}\left[\frac{1}{1 - \left(\dfrac{c'}{2\rho}\right)^2}\right]$$
$$\doteq m^2 D\left[1 + \left(\frac{c'}{2\rho}\right)^2\right] \tag{45}$$

In view of the earlier statement relative to the ratio $c' : \rho$, the second term within the braces in the last line of Eq. (45) is generally extremely small, so that

$$D' \doteq m^2 D \tag{46}$$

is an excellent approximation.

(c) Depth of Focus

The ratio of the near and far distances bounding the depth of focus is obtained by dividing Eq. (23) into Eq. (22):

$$\frac{p' - p'_{ne}}{p'_{fe} - p'} = \frac{D'_n}{D'_f} \tag{47}$$

According to Eq. (44), therefore, the near and far distances are approximately equal.

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A Comparison of Learning Resulting From Motion-Picture Projector and From Closed-Circuit TV Presentations

By J. F. McGRANE
and MORTON L. BARON

In an attempt to standardize Military Service requirements for motion-picture projector noise levels, training films at various projector noise levels were shown to students. The same films were also shown over a closed-circuit TV system to equivalent groups. A comparison of the results obtained with respect to "learning" is presented. Tests were made before and after each presentation. It is shown that the projector is the superior training device, provided low noise levels are maintained.

In a previous paper[1] an account of the work performed to standardize the Armed Services' requirements for permissible noise levels of motion-picture projectors and still projectors used for training purposes was described. In the experimental design, the study involved the projection of training films in the classrooms at the Signal School, Fort Monmouth, and the determination of the student's reactions when noise emanating from the projector was set at several levels. Control of noise level was made by acoustic covers over the projector in such a manner that the purpose was not apparent to the students. The results of the study are summarized in Fig. 1. It is seen that intelligibility increases with increasing "articulation index," which is complexly related to both noise and frequency of the noise.[1] Essentially, at constant frequency the "articulation index" increases with decreasing noise level.

At that time it was considered probable that either the projector or the closed-circuit-television (CCTV) method of teaching was significantly superior to the other. This problematical assumption could be verified if a comparison study, using the same techniques, could be performed. Fortunately, the identical films used in the noise-level study were scheduled for presentation to other classes over a CCTV system in use at the Signal School. Through the excellent cooperation of the School administration, schedules were arranged to show identical film, at the same time, to classes over CCTV and to equivalent classes using motion-picture projectors. The classroom arrangement is shown in Fig. 2. It should be noted that the same arrangement was used in the projector classes and in the CCTV classes, with the exception that in the latter the screen was replaced with a 21-in. TV receiver.

Presented on May 5, 1959, at the Society's Convention in Miami Beach by J. F. McGrane, American Machine & Foundry Co., Alexandria, Va., and Morton L. Baron (who read the paper), U.S. Army Signal Equipment Support Agency, Fort Monmouth, N.J.
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Experimental Design for the Study

In order to conduct the study properly, an experimental design was worked out in which three variables were considered: (1) noise level of projectors, (2) films and (3) groups or classes to whom the films were shown. See Fig. 3 for details of the variables. To reduce testing time and to stay within budget limitations, the variables were organized according to the method called a "Latin Square."[2] This method is one of the simplest and most important designs used when it is necessary to make only one measurement (scores of the tests given the students) which is affected by more than one variable. This method, although not effecting as deep a coverage of the variables as repetition would have permitted, was effective. The geometrical representation of the design is shown in Fig. 3.

The experimental arrangement was as follows: (1) Six groups of subjects (approximately 25 per group) were used: three for the projector and three for the CCTV. (2) Each of the six groups saw each of the three films. (3) Each of the three projector groups saw each film at a different noise level. (4) The noise level of the CCTV presentations was constant and was below the ambient level. (5) Corresponding projector classes and CCTV classes met at the same hour, day and week.

The statistical method used is called "analysis of variance,"[3] which is a method of comparing the scatter of a group of scores caused by the activity of an experimental variable with the scatter of the scores caused by nonexperimental ("error") factors. The sequence of analysis is as follows:

(1) Pre-test analysis:
   (a) Within projector and within CCTV means.
   (b) Between projector and CCTV means.

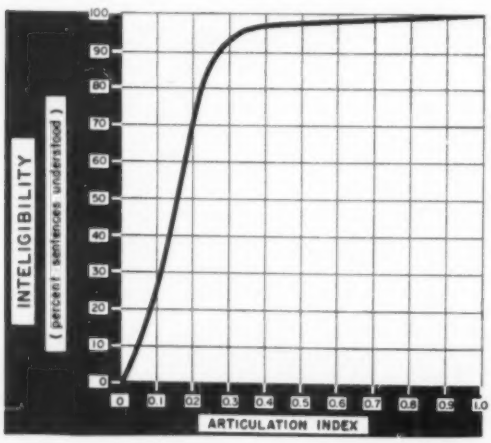

Fig. 1. Relationship between articulation index and intelligibility expressed as per cent of sentences understood.

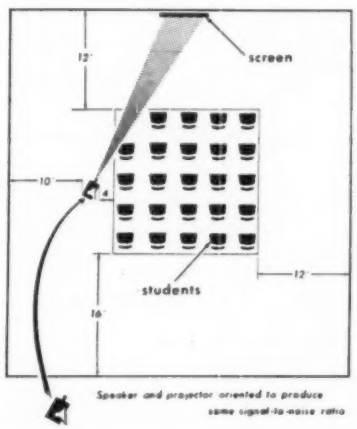

Fig. 2. Classroom arrangement for motion picture-projector presentation. For the TV classes, the screen was replaced by a 21-in. receiver.

Table I. Pre-Test Means of Scores Within Projector, With Different Noise Levels and Films.

Noise level, db	Scores for films: Capacitance	A.C.	Inductance	Totals
65	39.3	55.0	69.2	163.5
60	52.9	40.0	66.3	159.2
55	41.5	41.3	72.0	154.8
Totals	133.7	136.3	207.5	477.5

Table II. Pre-Test Means of Scores Within CCTV, With Different Noise Levels and Films.

Noise level, db	Scores for films: Capacitance	A.C.	Inductance	Totals
65	52.2	53.7	65.3	171.2
60	39.0	32.2	69.7	140.9
55	47.9	32.5	64.8	145.2
Totals	139.1	118.4	199.8	457.3

(2) Post-test analysis:
(a) Within projector and within CCTV means.
(b) Between projector and CCTV means.

We can anticipate that mean differences will be found; however, it is the "significance of this difference" with which we are primarily concerned. A 5% confidence level is presumed, meaning that we decided to be 95% certain of our conclusions. The concept of "significance levels" is given in Ref. 3.

Pre-Test Analysis

In interpreting projector-CCTV mean differences for each group, the pre-test scores must be considered. Those students with high pre-test scores cannot learn as much as those with lower scores since "learning" is defined as a difference between pre- and post-test scores. The purpose of this analysis is to determine whether there exist two types of mean differences: (1) within projector and CCTV means; and (2) between projector and CCTV means.

Clearly, the pre-test results can show effects neither of "noise levels" nor of "films." But the data are divided in the pre-test anaysis according to the groups which were subject to these variables so that pre- and post-test comparisons can be narrowed to specific variables. Tables I and II contain the pre-test means of the projector and CCTV groups.

Tables III and IV contain the analysis of variance of the pre-test means. In summary of these two analyses: No significant differences were found within the projector and CCTV results, as shown by the "significance level," except for the "films" variable of the CCTV means. This difference will be taken into account in evaluating the post-test results. With this one exception, differences arising in the post-test scores are attributable directly, therefore, not to differences in the amount of knowledge of the groups, but to the noise level and film content.

Table V contains the significance of the pre-test differences *between* the

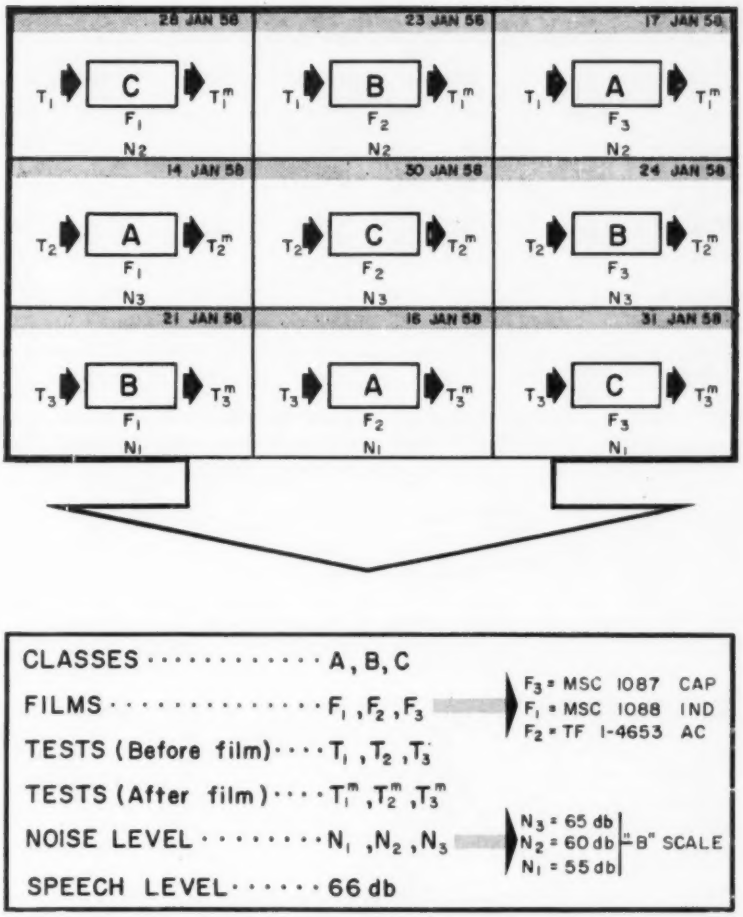

Fig. 3. Experimental design for the tests, incorporating three variables: Classes A, B and C; Noise levels 55, 60 and 65 db; and Films Capacitance, A-C Theory and Inductance.

Table III. Analysis of Variance of Pre-Test Means of Scores for Projector Method.

Variable	D.F.*	Sum of squares	Mean squares	F* ratio	Significance level*
Noise levels	2	12.61	6.31	0.06	above 0.05
Films	2	1169.18	584.59	5.379	above 0.05
Groups	2	31.0	15.50	0.14	above 0.05
Exper. error	2	217.35	108.68		
Totals	8	1430.14			

* *Ed. Note:* The reader is referred to the standard texts listed in the References and Bibliography at the end of the paper, for detailed definitions of the terms D. F. (degrees of freedom), F ratio and Significance Level.

Table IV. Analysis of Variance of Pre-Test Means of Scores for CCTV Method.

Variable	D.F.	Sum of squares	Mean squares	F ratio	Significance level
Noise levels	2	179.18	89.59	6.80	above 0.05
Films	2	1193.22	596.61	45.30	below 0.05
Groups	2	203.60	101.80	7.73	above 0.05
Exper. error	2	26.33	13.17		
Totals	8	1602.33			

Table V. Significance of Pre-Test Differences Between Projector and CCTV Means.

Groups			Mean values			Mean diff.		Std. deviation		Std. error of mean			
Film	Week	db	Proj.	N*	CCTV	N*	Abs. value	Proj.	CCTV	Proj.	CCTV	Std. error of diff.	Critical ratio
Capacitance	1	60	39.3	23	39.0	20	0.3	16.0	17.3	3.4	3.9	5.2	0.06
	2	65	52.9	24	52.2	23	0.7	20.5	19.1	4.3	4.1	5.9	0.12
	3	55	41.5	20	47.0	19	6.4	18.2	21.7	4.1	5.2	6.6	0.97
A.C.	1	55	40.0	23	32.5	20	7.5	21.0	14.3	4.5	3.3	5.6	1.34
	2	60	41.3	24	32.2	23	9.1	22.5	18.8	4.7	3.9	6.1	1.49
	3	65	55.0	20	53.7	19	1.3	24.3	19.8	5.5	4.7	7.2	0.18
Inductance	1	65	72.0	23	65.3	20	6.7	18.0	16.9	3.8	3.8	5.3	1.26
	2	55	69.2	24	64.8	23	4.4	17.9	17.5	3.7	3.7	5.2	0.84
	3	60	66.3	20	69.7	19	3.4	19.0	19.8	4.3	4.7	6.4	0.53

* Number of students tested.

Table VI. Post-Test Means of Scores for Projector Method, With Different Noise Levels and Films.

Noise level, db	Scores for films: Capacitance	A.C.	Inductance	Totals
65	14.38	1.00	−4.13	11.25
60	30.00	21.74	5.00	56.74
55	25.79	25.91	7.92	59.62
Totals	70.17	48.65	8.79	127.61

Table VII. Post-Test Means of Scores for CCTV Method, With Different Noise Levels and Films.

Noise level, db	Scores for films: Capacitance	A.C.	Inductance	Totals
65	20.2	6.3	8.3	34.8
60	29.0	24.8	6.1	59.9
55	25.3	21.0	6.1	52.4
Totals	74.5	52.1	20.5	147.1

Table VIII. Analysis of Variance of Post-Test Means of Scores for Projector Method.

Variable	D.F.	Sum of squares	Mean squares	F ratio	Significance level
Noise level	2	490.81	245.41	68.74	0.02
Films	2	646.60	323.30	90.56	0.01
Groups	2	67.73	33.87	9.49	above 0.05
Exper. error	2	7.14	3.57		
Totals	8	1212.28			

Table IX. Analysis of Variance of Post-Test Means of Scores for CCTV Method.

Variable	D.F.	Sum of squares	Mean squares	F ratio	Significance level
Noise level	2	110.67	55.34	2.23	above 0.05
Films	2	490.70	245.35	9.88	above 0.05
Groups	2	72.86	36.43	1.47	above 0.05
Exper. error	2	49.67	24.84		
Totals	8	723.90			

projector and CCTV means. In summary of the analysis: The significance of the difference *between* the projector and CCTV means is given in the "critical ratio" column of Table V. For a difference to be statistically meaningful, the ratio must be greater than 2.06. Since none of the ratios exceeds this value, each difference indicated is "chance," that is, insignificant. Hence, differences between post-test means can only reflect the differential effects of the experimental variables.

Post-Test Analysis

In studying the CCTV post-test data analyses, one point should be noted: There is no "noise level" variable; yet, a "noise level" variable is indicated in the tables. This pseudovariable means that corresponding data were procured at the same time, i.e., hour, day and week, as were the data under the same heading in the projector tables. Tables VI and VII contain the post-test means of the projector and CCTV groups, in units of "delta learning," post-test minus pre-test scores.

Tables VIII and IX contain the analysis of variance of the post-test means. In summary of these two analyses: Table VIII shows that both noise levels and films were active, significant variables. Table IX shows that no significant effects resulted from the "pseudonoise," film or group variables. Therefore, only when the projector was used were there significant mean differences attributable to films. Because no significant differences within the projector pre-test results were found, it can be assumed that differences in the post-test scores are attributable to the experimental variables. It is assumed in this type of interpretation that: (1) other variables not specifically considered (e.g., room, instructors, etc.) did not appreciably alter the results; and that (2) the methods of scoring and analyses are valid. It may be observed that the CCTV delta learning results showed no significant differences attributable to the film variable. But, as previously noted in the pre-test analysis summary, a bias existed. Although no firm conclusion will be expressed about this initial bias, it could have masked real differences in learning effected by the film variable.

Table X contains the significance of the post-test differences *between* the projector and CCTV means. In summary of the analysis: Unlike the pre-test analysis, where no significant differences were found, in the post-test analysis such differences are noted five times (asterisk notation). These differences are described in the conclusions.

Conclusions

The results of these analyses are more clearly summarized in Tables XI and XII. These tests indicate:

(1) At its lowest noise level (55 db), the projector is superior to the CCTV method of presentation.

(2) At its middle noise level (60 db), neither method is conclusively superior to the other.

(3) At its highest noise level, the CCTV is superior to the projector method.

(4) When compared by "films," with noise levels held constant, neither method is superior to the other.

The unequivocal conclusion drawn is that the projector and CCTV methods of film presentations do not result in equal amounts of learning. This conclusion is predicated on the reliability and validity of the pre- and post-tests used in the study. The tests and method of scoring have been designed as carefully as possible and therefore test validity may be assumed. Consistency of the results

Table X. Significance of Post-Test Differences Between Projector and CCTV Means.

Groups			Mean values			Mean diff.		Std. deviation		Std. error of mean		Std. error of diff.	Critical ratio
Film	Week	db	Proj.	N*	CCTV	N*	Abs. value	Proj.	CCTV	Proj.	CCTV		
Capacitance	1	60	29.6	23	29.0	20	0.6	17.4	16.0	0.79	0.84	1.14	0.53
	2	65	14.0	24	20.3	23	8.2	17.5	20.5	0.76	0.93	1.20	6.83**
	3	55	26.0	20	25.3	19	0.7	20.1	18.2	1.06	1.01	1.47	0.48
A.C.	1	55	26.1	23	21.0	20	5.1	14.4	21.0	0.65	1.11	1.29	3.95**
	2	60	21.5	24	24.8	23	3.3	22.3	22.5	0.97	1.02	1.41	2.34**
	3	65	2.0	20	6.3	19	4.3	14.7	24.3	0.77	1.35	1.55	2.77**
Inductance	1	65	4.1	23	8.3	20	12.4	19.8	18.0	0.90	0.94	1.30	9.54**
	2	55	7.9	24	6.1	23	1.8	22.7	17.9	0.99	0.81	1.28	1.41
	3	60	4.8	20	6.1	19	1.3	20.9	19.0	1.10	1.06	1.53	0.85

* Number of students tested.
** Significant difference.

from week to week during the testing program lends credence to their being considered "highly reliable." There is little question that both their reliability and validity could have been increased, regardless of their present merits, by adding more questions.

The authors have no positive evidence indicating why the CCTV method does not produce results comparable to those obtained with the quiet projector. Educated guesses would be that any or all of the following caused the difference: The smaller size of the TV screens, the lack of color, the lower resolution, eye fatigue induced by improper screen illumination (although the receivers were adjusted before each presentation) and last, but possibly of importance, the association of television with "recreation" rather than "education."

Table XI. Comparison of Projector and CCTV Results by Noise Levels.

Superior method	Noise level, db 65	60	55	Totals
Projector	0	1	3	4
CCTV	3	2	0	5
Total groups	3	3	3	9

Table XII. Comparison of Projector and CCTV Results by Films Used.

Superior method	Film designation Capacitance	A.C.	Inductance	Totals
Projector	2	1	1	4
CCTV	1	2	2	5
Total groups	3	3	3	9

References and Bibliography

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3. Bernard Ostle, *Statistics in Research: Basic Concepts and Techniques for Research Workers*, Iowa State College Press, Ames, 1954.
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The Standardized 16mm JAN Projector

By GEORGE W. REUTELL, JR.

The standardized 16mm JAN Sound Projector was established by the Projection Equipment Committee under Standardization Working Group 402-40E of F.S.C. Group 67. The transition from three different projectors used by the Army, Navy and Air Force to a single projector was accompanied by design improvements for the new projector. Available conversions and accessories for this standardized projector are also described.

THE Defense Cataloging and Standardization Act, Public Law 436, which was enacted by the 82d Congress and affirmed by the 84th Congress in Public Law 1028, authorized the Department of Defense Photographic Standardization Plans and resulted in the organization of the Projection Equipment Committee in February 1957. All of the Services were represented on this committee, of which Philip M. Cowett of the Bureau of Ships was chairman. Details of the Plans have been covered by Mr. Cowett in a previous paper (*Jour. SMPTE, 66:* 535–537, Sept. 1957).

The Committee Assignment

The equipment to be examined by the Project Equipment Committee for the purpose of standardizing, improving and making it more economical was the 16mm JAN Sound Projector used by all three Services. The three different types of the same basic projector design that were being used had considerable differences in features, finishes and applicable specifications. The differences between these projectors were reviewed along with proposed improvements and applicable specifications. This work resulted in an improved standard projector which, when combined with available conversions and accessories, provided the Services with equipment suitable for small classrooms as well as large auditoriums, reproducing either optical or magnetic sound. The machine could also be adapted for television use and to record magnetic sound.

History of JAN Projector Specifications

The specification for the JAN Projector was written by the ASA War Standards Committee on Photography and Cinematography Z52, Subcommittee "D" in September 1943. This specification was the basis for Signal Corps Specification MIL-P-14103, U.S. Navy Specification 18P12 and the Joint Army-Navy Specification JAN-P-49. Cooperation between the Services during the initial development of the projector resulted in a common basic design with modifications to suit the special requirements of each of the three Services. The significant differences in the three types of projectors that existed prior to standardization were as follows:

(1) The Signal Corps projector was designated Type AQ-2A(2); the Air Force, Type AQ-2A(1); and the Navy, Type AQ-2(1).

(2) The color of the entire case of the Navy and Air Force projectors was gray, while the Signal Corps projector case was olive drab with black hardware.

(3) The Navy specified single-branded 6AQ5 amplifier tubes, the Signal Corps double-branded and the Air Force triple-branded.

(4) The Air Force and the Signal Corps projector nameplates were reverse-etched aluminum and the Navy, direct-etched monel.

(5) The rotary main switch for the Signal Corps and Air Force projectors was a good commercial grade, whereas the Navy used a switch developed especially for the Navy.

(6) The power plug for the Air Force and Signal Corps projectors was a modified commercial grade, and that for the Navy projector was a type covered by a Military Specification.

(7) The Air Force did not require that slip-over covers for the projector be supplied, whereas the Navy specified a gray plastic cover with a glass-fiber lining and the Signal Corps an olive drab duck cover with a sponge-rubber lining.

(8) An hour counter was supplied on each projector for the Air Force and Signal Corps only.

(9) The basic mechanism for converting to complete change-over facilities was included only on the Navy projectors.

(10) The Signal Corps and Air Force projector wiring was fused on one side of the line, whereas the Navy projector wiring was fused on both sides of the line.

(11) In general, different specifications were specified by the three Services covering such items as the projector itself, finishes, lenses and lubricants.

These three projectors, then, were the units analyzed part for part by the committee, along with a number of design improvements, the details of which will be covered later in this paper.

Problems and Procedure of Committee

This committee had a somewhat tedious job owing to the rather large number of parts involved and the complex specifications covering the equipment. The changes that had resulted in greater differences in these projectors over a period of years, when it was not necessary for the Services to standardize their requirements, had to be resolved. The resolved changes, along with those solicited from industry, were submitted to Bell & Howell with the request that a prototype model be made.

Since technical responsibility for this projector was assigned to the U.S. Navy, Bureau of Ships, testing of the prototype model was performed at the Brooklyn Naval Testing Laboratories. From the information thus obtained, and the detail changes made in the projector and accessory equipment, the applicable specification was then rewritten as MIL-P-49C, which is expected to be released during 1959.

The cooperative spirit of this committee was apparent in that agreement on the Standardized JAN was reached within one year after its inception. This accomplishment is an example that should be recognized in relation to the standardization possibilities that do exist if the responsible parties are given the proper authority.

The Standardized JAN

The differences between projectors were resolved as follows:

(1) The type designation of the projector was changed to AQ-2A(3).

(2) The color of the case and painted castings is gray.

(3) Amplifier tubes are single-branded, which is the less costly type.

(4) The nameplate is etched monel, which is required by the Navy because of the extreme corrosive conditions encountered on shipboard.

(5) The main switch is the improved type developed by the Navy.

(6) The power plug is the bladed type, covered by a Military Specification, which is more suitable for the rugged usage encountered.

(7) The projector slip-over cover is gray duck with a sponge-rubber lining.

Presented on May 4, 1959, at the Society's Convention in Miami Beach, by George W. Reutell, Jr., Bell & Howell Co., 7100 McCormick Rd., Chicago 45.
(This paper was received on April 20, 1959.)

(8) An hour counter is included on each projector to facilitate maintenance.

(9) Basic parts for conversion to change-over were not included in this projector.

(10) The projector wiring is fused on both sides of the line to provide maximum safety.

(11) Applicable specifications were standardized in MIL-P-49C.

The improvements incorporated in the standardized JAN Projector were as follows:

(1) *Lubrication.* All bearings were changed to an improved oil-impregnated, powdered-metal bearing, and the shuttle is oiled by a recirculating system capable of running for 1000 hr without re-oiling. Formerly, the shuttle and the bearings were lubricated through a system of oil lines; oil had to be added by the operator every 100 hr.

(2) *Reel-arm drive belts.* The reel-arm drive belts were changed to neoprene-impregnated fabric capable of 500 hr of operation. These belts replace stainless-steel spring belts which averaged between 40 and 70 hr of operation and frequently failed as the projector was being operated, necessitating an interruption in showing of the film.

(3) *Drive clutch.* The take-up and rewind drive clutches were changed to a spring-loaded ball to ensure positive drive. Formerly, these balls were actuated by centrifugal force.

(4) *Photocell.* The photocell was changed to a germanium diode. This new cell has a distortion of less than 3%; a much higher percentage was encountered with the lead sulfide cell formerly used. Its sensitivity variation is less than ±3 db, whereas that of the lead sulfide cell can run as high as ±20 db. Another advantage of this photocell is that the polarizing voltage can vary up to 100% either side of nominal without affecting the output level.

This new cell, along with the necessary amplifier wiring changes, greatly improved the sound performance by reducing second harmonic distortion and simplifying amplifier adjustment initially as well as in the field. The initial cost of the germanium diode is higher, but it is expected that subsequent production runs and reduced projector manufacturing costs will eventually make it comparable to, or lower than, the PbS cell in cost.

(5) *Drive-motor resistor.* The drive-motor resistor was changed from 150 to 100 ohms to reduce radiated noise and increase brush life.

(6) *Projector legs.* The projector legs were changed to heat-treated steel in place of cast aluminum to reduce failure due to severe handling and meet the drop test requirements of MIL-P-49C.

(7) *Magnetic conversion.* Facilities for conversion to magnetic-optical reproduce

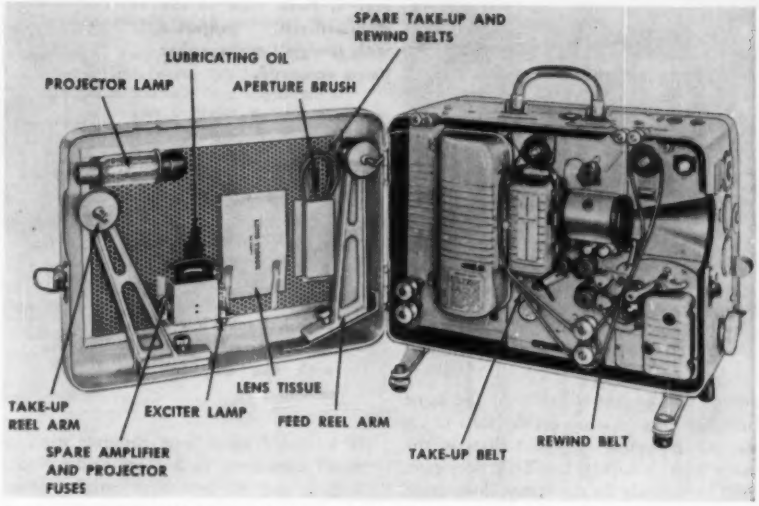


Fig. 1. Front view of the standardized JAN Projector with the door open.

were incorporated in the amplifier design. With this change, conversion is made merely by replacing the sound-head assembly.

(8) *Amplifier wiring.* Besides being changed to accommodate the new photocell, the design was changed from a semi-fixed bias to a self-bias system to extend output tube life. The "B" supply filter was also changed to reduce the hum modulation in the exciter supply, thereby improving the signal-to-noise ratio by approximately 10 db.

(9) *Spares.* Provisions were made to store a complete set of running spares within the projector. A set of reel-arm drive belts, exciter lamp, projector lamp, amplifier and projector fuse are stored on the projector door and a set of amplifier tubes, behind the removable amplifier panel.

(10) *Lens.* The rear condenser lens retainer was revised to facilitate removal for cleaning.

(11) *Tube shield.* A more efficient Nel type of heat-dissipating tube shield, developed by the Navy, was used to reduce the running temperature of the 6AQ5 tubes; tube temperatures were reduced from 220 to 185 C. This change, along with amplifier wiring changes, greatly extended tube life, as was evident from the results of the tests of the prototype unit. This unit ran in excess of 1000 hr without changing a tube and with no appreciable change in sound performance.

(12) *Exciter lamp socket.* An improved socket design was used to provide a more positive and safer construction.

(13) *Projector circuitry.* The complete projector circuitry was revised to reduce radio interference and radiated and conduced noise and to eliminate the necessity for shielding.

(14) *Hardening of parts.* The shuttle-spring mounting bracket and the intermediate drive-gear stud were heat-treated to reduce wear.

(15) *Speaker receptacle.* The external loudspeaker receptacle was changed to an improved type.

(16) *Sound shaft.* The sound-shaft bearings were changed from an unshielded type to a smaller, standard shielded type, and the method of spring loading was revised to a more positive design. This resulted in a more economical design and shielded the bearing against the harmful effects of dust or other foreign matter.

(17) *Motor brush removal.* A hole was added to the bottom of the projector case to facilitate replacement of the motor brush.

This completes the description of the changes made to effect standardization and to improve projector performance. The details for each of these changes were developed by the members of the committee and/or the Bell & Howell Company along with a number of other changes which were not adopted for various reasons. In the design and development of these changes, consideration had to be given to the available and proposed conversions and accessory equipment, to maintain standardization and flexibility. The standardized projector is shown in Figs. 1, 2 and 3.

Conversions Available

Facilities for picture and sound change-over when two projectors are used can be incorporated in the standardized projector to allow the showing of a film without interruption. Two projectors are connected with an interconnecting cable. Change-over is obtained by activating a pushbutton switch which operates a solenoid on each projector to lower a douser cutting off the light on one unit and simultaneously to raise the

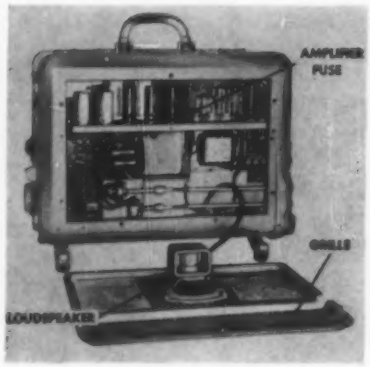


Fig. 2. Back view of the standardized projector with the grill and speaker panel removed.

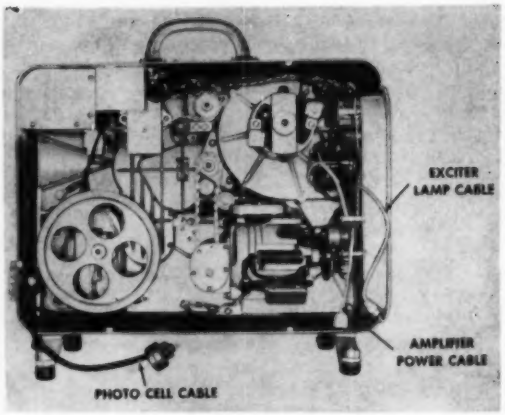


Fig. 3. Back view of the standardized projector with the amplifier removed.

douser on the second unit. At the same time the exciter lamp on the unit being cut out is turned *off* while that on the other unit is turned *on*. This projector, used extensively by the Navy, designated Type AQ-3(2), is identical to the standardized projector except that the necessary change-over parts are added.

Conversion to magnetic-optical reproduce is accomplished by merely replacing the soundhead assembly.

The standardized projector can also be converted to optical reproduce-magnetic reproduce and record. These conversions, available in kit form, can be accomplished in the field.

A special model of this same basic projector is utilized by TV stations. This model has facilities for reproducing optical or magnetic sound-tracks and is mounted on a pedestal which contains the switching panel and remote-control power supply, as shown in Fig. 4.

Accessory Equipment

Accessory equipment available includes a 16-ohm external loudspeaker, a booster amplifier and a mixer. These units are all matched and mounted in an individual case. If desired, the cases can be removed to mount the amplifier and mixer in a relay cabinet.

The booster amplifier is capable of 40-w output with a total harmonic distortion of less than 1%. It has an 8-ohm output to accommodate the external loudspeaker as well as a tap on the output transformer to accommodate a 70.7-v sound-distribution system. Means for bridging are also provided for increasing the power output to the desired amount. Frequency response is $\pm\frac{1}{2}$ db from 20 to 50,000 cycles/sec.

A three-channel mixer has also been developed for use with the booster amplifier. This mixer meets or exceeds broadcast performance requirements. Distortion is less than $\frac{1}{10}$ of 1% and the frequency response is $\pm\frac{1}{2}$ db from 20 to 50,000 cycles/sec.

It is apparent that this standardized JAN Projector, along with available conversion accessories, has an extremely wide application. With the ever-increasing use of training and entertainment film under conditions ranging from a small classroom to a large auditorium, and in any environment ranging from the tropics to the poles, this flexibility is mandatory from the standpoint of having the right equipment for the conditions encountered as well as having maintenance facilities and spare parts available at a minimum cost.

Standardization in Process

With the advent of the standardized JAN Projector, a most important initial step has been taken that will enable complete standardization and improvement of this projector and accessory equipment to realize the greatest possible cost savings. Standardization of the ordering, stocking and distribution of spares, detail drawings and technical manuals has been initiated but is not yet completed. Presently, each Service separately selects, orders and stocks the spares required. This also increases the cost of these spares in that the quantities are relatively small. The advantages of standardizing would certainly reflect a cost saving as well as facilitate maintenance throughout the wide areas in which this equipment is used.

Each of the Services currently requires a set of a different type of reproducible drawings and prints. The Navy uses the manufacturers' drawings, whereas the Signal Corps and Air Force require drawings to meet special requirements. In addition, a technical manual must be furnished with each projector. An entirely different manual is used by each of the Services.

Separate committees have been established for the purpose of standardizing drawings and technical manuals. The intent of the Defense Department standardization plans and the work accomplished by the Projection Equipment Committee have established the basic requirements for complete standardization of this equipment.

Fig. 4. The JAN Projector model used by TV stations.

Discussion

George Lewin (*Army Pictorial Center*): What about the spectral response of this new cell? It must be different, because I understand you get less distortion now with certain types of dye track.

Malcolm Townsley (*Bell & Howell Co.*): The germanium diode does have a different spectral response from the lead sulfide cell which was formerly used. The changing of the distortion characteristic, however, does not seem to be because of the spectral response change but because of the electrical characteristics of the photocell and the circuit in which it operates.

The following comment in response to Mr. Lewin's question was submitted in writing:

[*Mr. John Powers*, (*Bell & Howell Co.*): The germanium photodiode has its response peak at 13,000 A which is about the same as the high-frequency peak of the lead sulfide cell. However, the photodiode has no sensitivity past 19,000 A, while the lead sulfide cell has a very broad peak at 22,000 A. The germanium photodiode also has sensitivity in the visible portion of the spectrum in the 300 to 7000-A range while the lead sulfide cell has almost no sensitivity in this range.]

Mr. Lewin: You spoke of the magnetic conversion. Does this mean that the projector reproduces sound primarily from optical track?

Mr. Reutell: The projector is basically an optical. The conversions that I spoke of allow the use of either magnetic or optical soundtracks.

Mr. Lewin: Is the figure of 3% a harmonic distortion? I assume it has nothing to do with the distortion you sometimes get from color soundtracks?

Mr. Townsley: That is correct.

J. Kenneth Lewis (*Dept. of Defense, National Security Agency*): Is this projector now available, and also the kits?

Mr. Reutell: The projector and the conversion kits are available.

International Standardization

The International Organization for Standardization (ISO), whose activities in the field of cinematography were described in the January 1959 *Journal* report, pp. 32–37, has recently adopted six Recommendations which are published here for the general information of the SMPTE membership. This now brings the total of ISO Recommendations adopted to thirteen. The first seven were published in the December 1957 SMPTE *Journal*.

The members' attention is directed to the fact that only the technical content of the Recommendations is published here. Copies of the complete documents including a brief history of the origin of each recommendation are available from the American Standards Association, 10 East 40 St., New York 16, for a nominal fee.

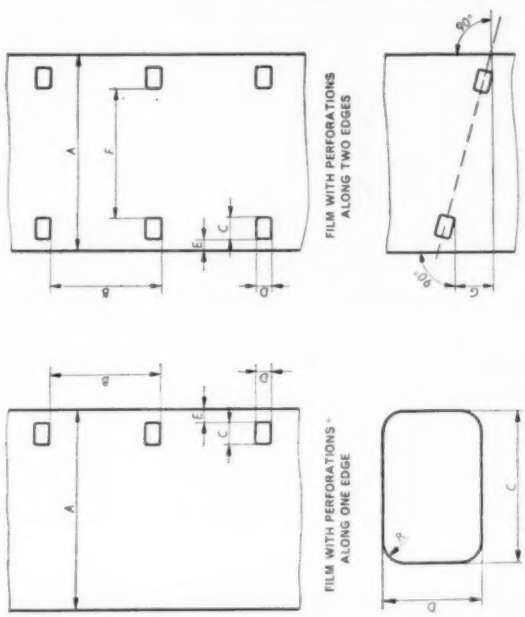
ISO/R 69-1958 (E)

ISO Recommendation R 69 December 1958

CINEMATOGRAPHY

DIMENSIONS FOR 16 mm MOTION-PICTURE FILM

WITH PERFORATIONS ALONG ONE AND TWO EDGES


FILM WITH PERFORATIONS ALONG TWO EDGES
FILM WITH PERFORATIONS ALONG ONE EDGE
Detail of perforation
Permissible alignment deviation of the rows of perforations

Dimension	Millimeters		Inches	
*A**	15.95	± 0.025	0.628	± 0.001
B	7.620	± 0.013	0.3000	± 0.0005
C	1.83	± 0.01	0.0720	± 0.0004
D	1.27	± 0.01	0.0500	± 0.0004
*E**	0.90	± 0.05	0.0355	± 0.0020
F	10.490	± 0.025	0.413	± 0.001
G	0.025	max.	0.001	max.
*L***	762.00	± 0.76	30.00	± 0.03
R	0.25		0.010	

* These dimensions are for low-shrink film base, as defined in the note. For film base with higher shrinkage characteristics *A* is 15.98 mm ± 0.025 mm (0.629 in ± 0.001 in) and *E* is 0.91 mm ± 0.05 mm (0.036 in ± 0.002 in).

** Dimension *L* represents the length of any 100 consecutive perforation intervals.

These dimensions and tolerances apply to the material immediately after cutting and perforating.

Experience shows that it is common for film to expand when exposed to high relative humidity. Allowance should be made for this factor in equipment design and in no case should the equipment design fail to accommodate a film width of 16.00 mm (0.630 in).

Note

For the purpose of this specification, low-shrink film base is a film base which, when coated with emulsion and any other normal coating treatment, perforated, kept in the container packed by the manufacturer for six months, exposed, processed and stored exposed to air having a temperature of 18 °C to 24 °C and a relative humidity of 50 per cent to 60 per cent, for not more than 30 days, and measured under like conditions of temperature and humidity, shall have shrunk not more than 0.2 per cent from its original dimension at the time of perforating.

ISO Recommendation R 70 December 1958

CINEMATOGRAPHY

PHOTOGRAPHIC SOUND RECORD ON 35 mm PRINTS

1. SCOPE

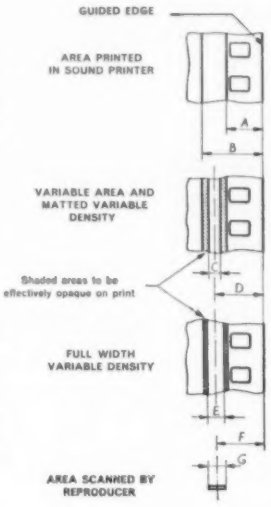
1.1 This ISO Recommendation specifies the location and dimensions of variable area and variable density sound records for the photographic printing of sound on 35 mm sound motion-picture prints. Also specified is the area scanned in the sound reproducer.

2. DIMENSIONS

2.2 The dimensions are as specified in the figures and table.

2.3 The sound record as printed on the film is displaced from the center of the corresponding picture by a distance of 21 frames ± ½ frame in the direction of film travel during normal projection.

2.4 When the distance from the center of the projector gate to the sound scanning point is 20 frames, the picture and sound are in synchronism for an observer at a distance of 15 m (50 ft) from the speaker.



Dimension	Millimeters	Inches
A	4.88 ± 0.02	0.192 ± 0.001
B	7.83 ± 0.05	0.308 ± 0.002
C	1.93 ± 0.02	0.076 ± 0.001
D	6.17 ± 0.05	0.243 ± 0.002
E	2.54 $^{+0.00}_{-0.20}$	0.100 $^{+0.000}_{-0.008}$
F	6.19 ± 0.05	0.244 ± 0.002
G	2.13 ± 0.02	0.084 ± 0.001

ISO Recommendation R 71 December 1958

CINEMATOGRAPHY

PHOTOGRAPHIC SOUND RECORD ON 16 mm PRINTS

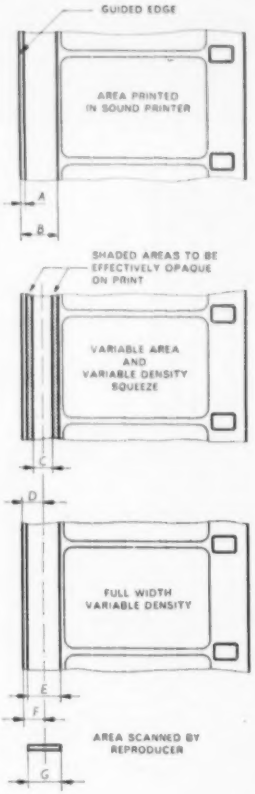
1. SCOPE

1.1 This ISO Recommendation specifies the location and dimensions of variable area and variable density sound records for the photographic printing of sound on 16 mm motion-picture film perforated along one edge. Also specified is the area scanned in the sound reproducer.

2. DIMENSIONS

2.1 The dimensions are as specified in the figures and table.

2.2 The sound is displaced from the center of the corresponding picture by a distance of 26 frames ± ½ frame in the direction of film travel during normal projection.



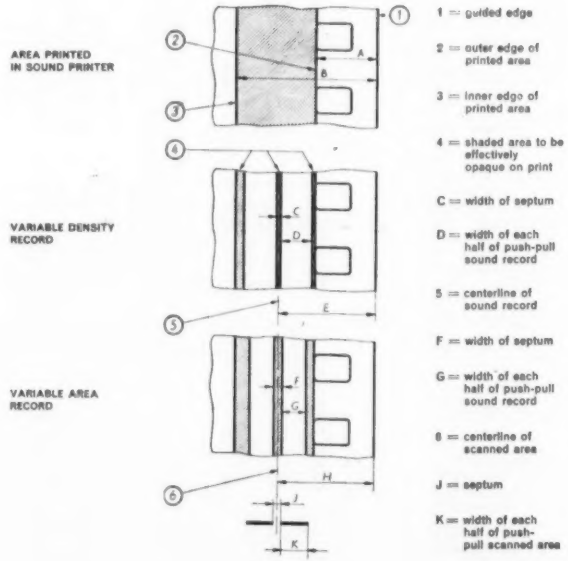
Dimension	Millimeters	Inches
A	0.16 max.	0.018 max.
B	2.79 max. 2.49 min.	0.110 max. 0.098 min.
C	1.52 $^{+0.15}_{-0.03}$	0.060 $^{+0.006}_{-0.001}$
D	1.47 ± 0.05	0.058 ± 0.002
E	2.03 $^{+0.10}_{-0.03}$	0.080 $^{+0.004}_{-0.001}$
F	1.47 ± 0.03	0.058 ± 0.001
G	1.83 max. 1.78 min.	0.072 max. 0.070 min.

ISO Recommendation R 72 December 1958

CINEMATOGRAPHY

SOUND RECORDS AND SCANNING AREA OF 35 mm DOUBLE WIDTH PUSH-PULL SOUND PRINTS

NORMAL AND OFFSET CENTERLINE TYPES



1 = guided edge

2 = outer edge of printed area

3 = inner edge of printed area

4 = shaded area to be effectively opaque on print

C = width of septum

D = width of each half of push-pull sound record

5 = centerline of sound record

F = width of septum

G = width of each half of push-pull sound record

8 = centerline of scanned area

J = septum

K = width of each half of push-pull scanned area

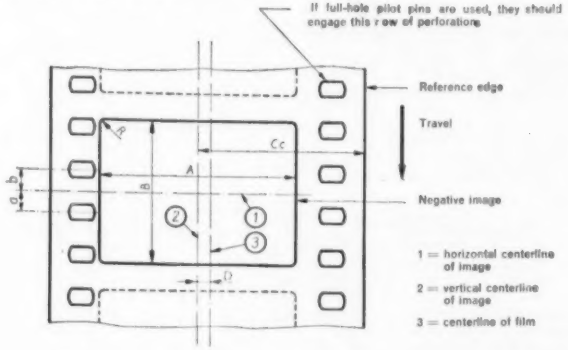
Dimension	Normal centerline type		Offset centerline type	
	Millimeters	Inches	Millimeters	Inches
A	4.85 ± 0.05	0.191 ± 0.002	4.85 ± 0.05	0.191 ± 0.002
B	10.66 min.	0.420 min.	10.66 min.	0.420 min.
C	0.254 ± 0.038	0.0100 ± 0.0015	0.254 ± 0.038	0.0100 ± 0.0015
D	2.41 ± 0.05	0.095 ± 0.002	2.41 ± 0.05	0.095 ± 0.002
E	7.44 ± 0.05	0.293 ± 0.002	7.98 ± 0.05	0.314 ± 0.002
F	0.61 ± 0.03	0.024 ± 0.001	0.61 ± 0.03	0.024 ± 0.001
G	1.93 ± 0.03	0.076 ± 0.001	1.93 ± 0.03	0.076 ± 0.001
H	7.44 ± 0.03	0.293 ± 0.001	7.98 ± 0.03	0.314 ± 0.001
J	0.41 ± 0.03	0.016 ± 0.001	0.41 ± 0.03	0.016 ± 0.001
K	2.13 ± 0.05	0.084 ± 0.002	2.13 ± 0.05	0.084 ± 0.002

ISO Recommendation R 73 December 1958

CINEMATOGRAPHY

IMAGE PRODUCED BY CAMERA APERTURE AND PROJECTED IMAGE AREA FOR 35 mm FILMS

1. Image produced by camera aperture



1 = horizontal centerline of image

2 = vertical centerline of image

3 = centerline of film

The dimensions are shown relative to unshrunk film.

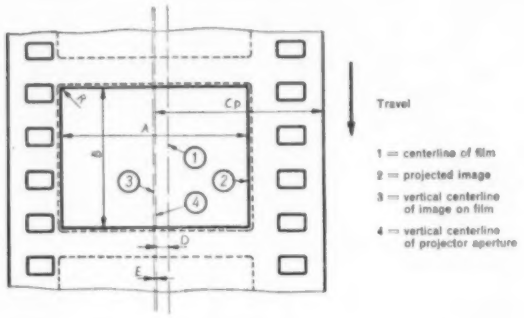
Film as seen from inside the camera, looking toward the camera lens.

Dimension	Millimeters	Inches
A	22.00 $^{+\ 0.10}_{-\ 0.00}$	0.866 $^{+\ 0.004}_{-\ 0.000}$
B	16.00 $^{+\ 0.10}_{-\ 0.00}$	0.629 $^{+\ 0.004}_{-\ 0.000}$
Cc	18.75 ± 0.05	0.738 ± 0.002
D *	1.40	0.055
R **	0.8 max.	0.03 max.
$a = b \pm 0.2$ mm or $b \pm 0.008$ in.		

* Dimension *D* is determined from other standardized dimensions.

** Radius of corners.

2. Projected image area



Note: D is the distance between lines 1 and 4.

Film as seen from the position of the projector light source, looking toward the lens.

The dimensions are shown relative to unshrunk film.

Dimension	Millimeters	Inches
A	21.00 max.	0.827 max.
B	15.30 max.	0.602 max.
Cp	18.75 ± 0.05	0.738 ± 0.002
D *	1.24	0.049
E	0.15 max.	0.006 max.
R **	0.15 max.	0.006 max.

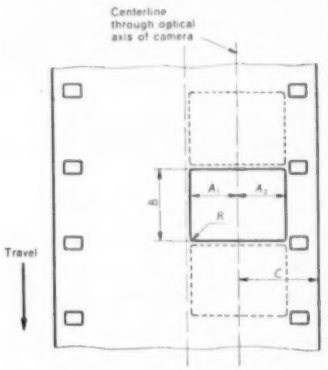
* Dimension D is determined from other standardized dimensions.
** Radius of corners.

ISO Recommendation R 74 December 1958

CINEMATOGRAPHY

IMAGE PRODUCED BY CAMERA APERTURE AND PROJECTED IMAGE AREA FOR 8 mm FILMS

1. Image produced by camera aperture



The camera aperture plate and the camera film registration device should be so related dimensionally that the framelines between the images are coincident with the centerlines of the sprocket holes.

The angle between the vertical edges of the aperture and the edges of normally positioned film should be $0° \pm 1/2°$.

The angle between the horizontal edges of the aperture and the edges of normally positioned film should be $90° \pm 1/2°$.

Film as seen from inside camera, looking toward the lens.

Dimension	Millimeters	Inches	Observations
A_1	2.39 min. 2.64 max.	0.094 min. 0.104 max.	See Note 1
A_2	2.39 min.	0.094 min.	See Note 1
B	3.51 $^{+\ 0.200}_{-\ 0.025}$	0.138 $^{+\ 0.008}_{-\ 0.001}$	See Note 1
C	5.21 ± 0.05	0.205 ± 0.002	See Note 2
R	0.25 max.	0.010 max.	See Note 1

Note 1: Dimensions A, B and R apply to the size of the image at the plane of the emulsion; the actual picture aperture has to be slightly smaller. The exact amount of this difference depends on the lens used and on the separation of the emulsion and the physical aperture. This separation should be no larger than is necessary to preclude scratching of the film. The greatest difference between the image size and the aperture size occurs with short focal-length, large diameter lenses.

It is desirable to hold the vertical height of the actual aperture to a value that will insure a real (unexposed) frameline. This results in less distraction when the frameline is projected on the screen than is the case when adjacent frames overlap.

Note 2: The value of dimension C has been chosen on the assumption that the film will have a slight shrinkage, when it is run through the camera. This is the normal condition.

ISO/R 74-1958 (E)

2. Projected image area

The projector aperture plate and the stopping position of the projector registration device should be so dimensionally related that the centerlines of the film image and plate aperture are coincident. (See Note 3.)

The angle between the vertical edges of the aperture and the edges of normally positioned film should be 0° ± ½°.

The angle between the horizontal edges of the aperture and the edges of normally positioned film should be 90° ± ½°.

Film as seen from inside projector, looking toward the lens.

Dimension	Millimeters	Inches	Observations
A	4.37 ± 0.025	0.172 ± 0.001	See Note 1
B	3.28 ± 0.025	0.129 ± 0.001	See Note 2
C	5.21 ± 0.050	0.205 ± 0.002	
R	0.25 max.	0.010 max.	

Note 1: Dimensions *A*, *B* and *R* apply to the portion of the image on the film that is to be projected; the actual opening in the aperture plate has to be slightly smaller. The exact amount of this difference depends on the lens used and on the separation of the emulsion and the physical aperture. To minimize the difference in size and make the image of the aperture as sharp as practicable on the screen, this separation should be no larger than is necessary to preclude scratching of the film.

When the reduction in size from the image to the actual aperture is being computed, it is suggested a 25 mm (1 in) f/1.6 lens be assumed, unless there is reason for doing otherwise.

Note 2: The limiting aperture is generally between the film and the light source so that it will give the maximum protection from heat. If other factors are more important, it may be on the other side of the film.

Note 3: It is customary to provide a framing movement of approximately 0.6 mm (0.025 in) above and below the nominal position of the film image.

standards and recommended practices

Proposed American Standards

A Proposed American Standard, PH22.117, Spectral Diffuse Density of Photographic Sound Record on Three-Component Subtractive Color Films, is published here for a three-month period of trial and comment.

In 1955, the Color Committee was asked to study the problem of standardizing methods for measuring the densities of color film and soundtracks. A subcommittee, chaired by Harry P. Brueggemann, was appointed to explore the needs of the motion-picture industry in the general field of color film densitometry. The proposal submitted by the subcommittee was revised and recirculated to the Color Committee four times before it was reviewed and approved by the Standards Committee.

Proposed American Standard Dimensions for 65mm Motion-Picture Film, KS-1870, PH22.118 and Dimensions for 70mm Motion-Picture Film, Perforated 65mm, KS-1870, PH22.119, have been approved by the Film Dimensions and Standards Committees. The proposals are published here for a three-month period of trial and criticism.

All comments should be addressed to Society Headquarters, attention of J. Howard Schumacher, Staff Engineer, prior to March 15, 1960. If no adverse comments are received, the proposals will be submitted to ASA Sectional Committee PH22 for further processing as American Standards.——*J.H.S.*

Proposed American Standard

Spectral Diffuse Density of Photographic Sound Record on Three-Component Subtractive Color Films

PH22.117

Supplement to PH2.19-1959 and PH2.1-1952

INTRODUCTION

The American Standard Spectral Diffuse Densities of Three-Component Subtractive Color Films, PH2.1-1952, which applies primarily to picture on color film, constitutes the basis for this standard, and Sections 2, 3 and 4 of that standard are to be considered part of the present standard.

The purpose of this standard is to supplement the American Standard Spectral Diffuse Densities of Three-Component Subtractive Color Films, PH2.1-1952, by specifying spectral conditions suitable for determining the sensitometric characteristics of photographic sound record on three-component subtractive color films. The conditions of this standard are intended for, and are applicable to, systems of sound reproduction using the S-1 photosurface, since this photosurface is in common use at the present time. It is recognized that there are other types of photosurfaces sometimes used for photographic sound reproduction that do not fall within the scope of this standard.

In three-component subtractive color films, dyes or color couplers are used to form the photographic image. These color materials are designed primarily for the visual region, but sound-record reproduction via the S-1 photosurface uses the infrared region of approximately 700 mμ (millimicrons) to 900 mμ, which is far enough away from the visual region so that the color materials cannot be used efficiently, but close enough so that they produce a measurable effect. The spectral characteristics of this effect depend on the type of light-absorbing material used for the sound record, and on the manner in which the sound record is processed. Therefore, in order to obtain uniformity of sound record densitometry among different films, and among the different density measuring instruments, it is necessary to specify the spectral conditions under which these density measurements are made. It is the aim of this standard to define these conditions sufficiently to insure reasonable uniformity of density measurements, yet not so rigidly as to make impractical the obtaining of such measurements.

This standard defines a primary condition which shall be the ideal method of taking density measurements of sound record on subtractive color films. This standard also defines a practical condition by means of which it is expected that most density measurements will be made.

If the accuracy required is less than that provided by the practical condition, it does not seem economical to use an instrument designed specifically for sound record. An instrument which measures in the visual region, perhaps with minor modifications to favor the general infrared region, will suffice.

1. Purpose and Scope

1.1 The principal purpose of this standard is to supplement American Standard Diffuse Transmission Density PH2.19-1959, and, further, to supplement American Standard Spectral Diffuse Densities of Three-Component Subtractive Color Films, PH2.1-1952.

1.2 This standard defines conditions suitable for integral spectral density measurement of photographic sound record on three-component subtractive color films.

1.3 It is recognized that there are other useful types of photographic sound-record density measurements that do not fall within the scope of this standard.

2. American Standard Diffuse Density

2.1 The following sections of the American Standard Diffuse Density PH2.19-1959, are part of the American Standard Spectral Diffuse Density of Photographic Sound Record on Three-Component Subtractive Color Films:

2. General Definition of Density

3. Totally Diffuse Density

4. American Standard Diffuse Density

3. American Standard Spectral Diffuse Densities of Three-Component Subtractive Color Films

3.1 The following section of the American Standard Spectral Diffuse Densities of Three-Component Subtractive Color Films, PH2.1-1952, is part of the American Standard Spectral Diffuse Density of Photographic Sound Record on Three-Component Subtractive Color Films:

2. Terminology Used in the Densitometry of Color Film

4. Terminology Used in the Densitometry of Photographic Color Sound Records

4.1 *Peak Response.* The peak response of a densitometer is the wavelength to which the densitometer has the greatest response, including such factors as the spectral emission of the light source, the combined spectral transmission of all optical filters in the light path, and the spectral sensitivity of the photosensitive receptor.

4.2 *Bandwidth.* The bandwidth of a densitometer is the range of wavelengths to which the densitometer is sensitive. In a practical densitometer this range of wavelengths is not sharply defined; but for the purposes of this standard, the bandwidth shall be considered to lie between those wavelengths which excite, in the photosensitive receptor, one-half the current which is excited at the wavelength of peak response. These limiting wavelengths are to be measured or computed using the light source, all operating optical filters, and the photosensitive receptor of the densitometer.

4.3 *Overall Response.* The overall response of a densitometer is the integrated response of the densitometer to all wavelengths, including such factors as the spectral emission of the light source, the combined spectral transmission of all optical filters in the light path, and the spectral sensitivity of the photosensitive receptor.

5. Potassium Infrared Diffuse Density

5.1 Potassium infrared diffuse density is diffuse density measured with energy concentrated in the spectral doublet of wavelengths 766.5 and 769.9 mμ of a potassium arc.

6. American Standard Spectral Density of Photographic Sound Record on Three-Component Subtractive Color Films

6.1 American Standard spectral diffuse density of photographic sound record on three-component subtractive color films is American Standard diffuse transmission density measured in any practical instrument with any practical condition which is proven by test to yield densities not significantly different from potassium infrared diffuse density, providing that the peak response of such a practical instrument is 768 ± 5 mμ, that the bandwidth of such an instrument is 20 mμ or less, and that the response of such instrument within the band from 758 to 778 mμ is at least 80 percent of the overall response.

Proposed American Standard

Dimensions for 65mm Motion-Picture Film, KS-1870

PH22.118

1. Scope

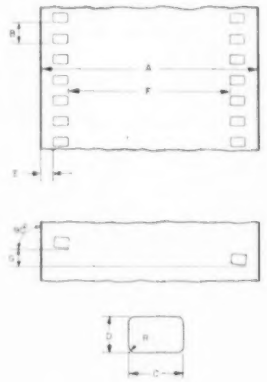
1.1 This standard specifies the cutting and perforating dimensions of 65mm motion-picture film.

2. Dimensions

2.1 The dimensions shall be as given in the diagram and table.

2.2 These dimensions apply to material immediately after cutting and perforating.

2.3 Dimension L represents the length of any 100 consecutive pitch intervals.



Dimensions	Inches	Millimeters
A Film width	2.558 ± 0.002	64.97 ± 0.05
B Length pitch	0.1870 ± 0.0005	4.750 ± 0.013
C Perforation width	0.1100 ± 0.0004	2.794 ± 0.010
D Perforation height	0.0780 ± 0.0004	1.981 ± 0.010
E Edge to perforation	0.117 ± 0.003	2.95 ± 0.08
F Width between perforations	2.104 ± 0.003	53.44 ± 0.08
G Perforation skewness	0.002 max	0.05 max
L Length pitch (100 consecutive pitch intervals)	18.700 ± 0.015	474.98 ± 0.38
R Radius of perforation fillet	0.020 ± 0.001	0.51 ± 0.03

NOTES

1. The title of this standard was established by the application of a nomenclature system developed for all film dimension standards: Each title provides an indication of the film width, the perforation shape (BH, KS, DH or CS) or the number of rows of perforations (1R, 2R or 4R), depending upon which is the significant factor, and the perforation pitch without the decimal point.

2. The dimensions in the inch system are the fundamental standard. The dimensions in the metric system are practical approximations based on American Standard Inch-Millimeter Conversion for Industrial Use, B48.1-1933, reaffirmed in 1947, providing a conversion factor of 1 inch = 25.4 millimeters.

APPENDICES

(These Appendices are not a part of American Standard Dimensions for 65mm Motion-Picture Films, KS-1870, PH22.118, but are included to facilitate its use.)

APPENDIX 1

The dimensions given in this standard represent the practice of film manufacturers in that the dimensions and tolerances are for film immediately after perforation. The punches and dies themselves are made to tolerances considerably smaller than those given, but since film is a plastic material, the dimensions of the slit and perforated film never agree exactly with the dimensions of the slitters, punches and dies. Film can shrink or swell due to loss or gain in moisture content or can shrink due to loss of solvent. These changes invariably result in changes in the dimensions during the life of the film. The change is generally uniform throughout a roll.

APPENDIX 2

The uniformity of pitch, margin and hole size (Dimensions B, C, D and E) is an important variable affecting steadiness. Variations in these dimensions, from roll to roll, are of little significance compared to variations from one sprocket hole to the next. Actually it is the maximum variation from one sprocket hole to the next within any small group of consecutive perforations that is important.

APPENDIX 3

Film of this size is generally used as a camera negative. There are two advantages in using this larger size. One is the possibility of producing large prints by contact printing for exhibition in special theaters designed to provide the audience with a large viewing angle. The other purpose is to serve as an original from which 35mm prints can be produced by reduction with less grain and better definition than is obtained by making contact prints from 35mm negatives.

Prints may be made on 70mm film. The appropriate film is described in Proposed American Standard Dimensions for 70mm Motion-Picture Film, Perforated 65mm, KS-1870, PH22.119. Note that the 70mm film used with 65mm negative differs in its dimensions from the two earlier films described by American Standard Dimensions for 70mm Unperforated and Perforated Film for Cameras Other Than Motion-Picture Cameras, PH1.20-1956, Type I and Type II. The perforations of the related 70mm film have the same size and pitch as those described by PH1.20-1956, Type II, but the margin and distance between perforations are different. Consequently Dimension F is the same in both the 65mm, KS-1870 film, and the 70mm, perforated 65mm, KS-1870. The increased space provided by a larger margin E is used to make room for magnetic soundtracks.

Note that the image usually placed on this film is five pitches high. The manufacture of the film is based on this idea and best results accrue from using this format. The pitch of the negative is nominal since the printing of film of this size is currently done by the use of step printers.

Proposed American Standard

Dimensions for 70mm Motion-Picture Film, Perforated 65mm, KS-1870

PH22.119

1. Scope

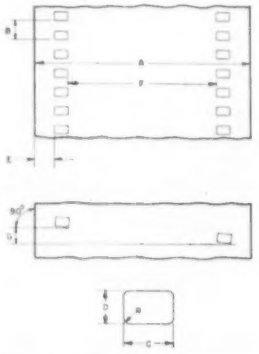
1.1. This standard specifies the dimensions of 70mm motion-picture film, perforated 65mm.

2. Dimensions

2.1 The dimensions shall be as given in the diagram and table.

2.2 These dimensions apply to material immediately after cutting and perforating.

2.3 Dimension L represents the length of any 100 consecutive pitch intervals.



Dimensions	Inches	Millimeters
A Film width	2.754 ± 0.002	69.95 ± 0.05
B Length pitch	0.1870 ± 0.0005	4.750 ± 0.013
C Perforation width	0.1100 ± 0.0004	2.794 ± 0.010
D Perforation height	0.0780 ± 0.0004	1.981 ± 0.010
E Edge to perforation	0.215 ± 0.003	5.46 ± 0.08
F Width between perforations	2.104 ± 0.003	53.44 ± 0.08
G Perforation skewness	0.002 max	0.05 max
L Length pitch (100 consecutive pitch intervals)	18.700 ± 0.015	474.98 ± 0.38
R Radius of perforation fillet	0.020 ± 0.001	0.51 ± 0.03

NOTES

1. The title of this standard was established by the application of a nomenclature system developed for all film-dimension standards: Each title provides an indication of the film width, the perforation shape (BH, KS, DH or CS) or the number of rows of perforations (1R, 2R or 4R), depending upon which is the significant factor, and the perforation pitch without the decimal point.

2. The dimensions in the inch system are the fundamental standard. The dimensions in the metric system are practical approximations based on American Standard Inch-Millimeter Conversion for Industrial Use, B48.1-1933, reaffirmed in 1947, providing a conversion factor of 1 inch = 25.4 millimeters.

APPENDICES

(These Appendices are not a part of American Standard Dimensions for 70mm Motion-Picture Film, Perforated 65mm, KS-1870, PH22.119, but are included to facilitate its use.)

APPENDIX 1

The dimensions given in this standard represent the practice of film manufacturers in that the dimensions and tolerances are for film immediately after perforation. The punches and dies themselves are made to tolerances considerably smaller than those given, but since film is a plastic material, the dimensions of the slit and perforated film never agree exactly with the dimensions of the slitters, punches and dies. Film can shrink or swell due to loss or gain in moisture content or can shrink due to loss of solvent. These changes invariably result in changes in the dimensions during the life of the film. The change is generally uniform throughout a roll.

APPENDIX 2

The uniformity of pitch, margin and hole size (Dimensions B, C, D and E) is an important variable affecting steadiness. Variations in these dimensions, from roll to roll, are of little significance compared to variations from one sprocket hole to the next. Actually it is the maximum variation from one sprocket hole to the next within any small group of consecutive perforations that is important.

APPENDIX 3

Film described in this standard is used in making prints from 65mm film described in Proposed American Standard Dimensions for 65mm Motion-Picture Film, KS-1870, PH22.118. Note that this film differs from the other 70mm films described in American Standard Dimensions for 70mm Unperforated and Perforated Film for Cameras Other Than Motion-Picture Cameras, PH1.20-1956, Types I and II.

news and reports

Activity in preparation for this outstanding event, sponsored by the SMPTE for reports on instrumentation and high-speed photography techniques and equipment from all over the world, is steadily advancing. The list of eleven National Delegates from other countries published in the September *Journal* has now been increased by two:

Civ. Ing. Tryggve Ramqvist
Försvarets Forskningsanstalt
Stockholm 80, Sweden

Kay Weedon
Boks 137
Ramstad near Oslo, Norway

Preliminary Author Forms for those wishing to submit papers for the Congress may be obtained from Society headquarters, Congress Chairman Max Beard, 10703 E. Nolcrest Dr., Silver Spring, Md., or from the Topic Chairmen whose names were listed in the November *Journal*, p. 771. A folder announcing the Congress, which will take place at the Sheraton-Park Hotel, Washington, D.C., October 16–22, 1960, is also available from Society headquarters.

87th Papers Program

Deadline for Author Forms to be submitted by Topic Chairmen to the Program Chairman is February 15 — authors must complete their plans and forms somewhat earlier to be assured of the most desirable scheduling.

Recognition of a rapidly broadening field of industry interest will be shown by a substantial group of papers on space age motion pictures and television. Other sessions will include new techniques in industrial and educational films, sound recording in instrumentation photography, and film and television training from the international point of view.

The topics and chairmen were listed on p. 772 of the November *Journal*. Forms and other information are available from Society headquarters and from: **Herbert E. Farmer,** 87th Convention Program Chairman, c/o Cinema, Univ. of Southern Calif., University Park, Los Angeles 7, Calif.

The 87th Convention, which will include an Equipment Exhibit, will be held May 1–7, 1960, at the Ambassador Hotel, Los Angeles.

The 86th Convention, New York

The Theme of the recent Convention in New York was *Motion Pictures and Television in the Age of Space*, an impressive reminder of the long, long way the Society (and civilization) has traveled in the 43 years since the Society was founded. In 1916, discussions of space probes, space vehicles, soft landings on the Moon and Man's personal exploration of space would have seemed utter madness, placed in serious context. It is a tribute to the Society's (and Man's) adaptability that the papers presented by distinguished scientists during the two sessions on Space Technology and Image Sensing represent an application of the art and science of motion-picture and television engineering which is accepted today, if not exactly as a commonplace, at least as a logical extension of the Society's sphere of interest.

The keynote speech, delivered by Edward P. Curtis, on Engineering in the Space Age, stressed that "any engineering activity must be evaluated and considered in the framework of Man's entry into the Space Age."

One of the especially appropriate moments of the Convention occurred at the Get-Together Luncheon when President Norwood Simmons acknowledged on behalf of the Society the "dedicated behind-the-scenes work" of the men who labored diligently to make the Convention a success. He thanked especially Glenn Matthews "our very able Editorial Vice-President" and Reid Ray "our most energetic Convention Vice-President" for their "usual expert handling" of the duties of their offices which are basic for all successful conventions.

The entire program maintained the high standards set by the Space Sessions, a credit to the painstaking efforts of Program Chairman J. Paul Weiss. An innovation in the development of this Convention was an advance announcement in July which contained the detailed program for two full days—Tuesday's Space Technology Sessions organized by Sidney Sternberg and Thursday's Sessions on Television Equipment and Practices developed by Ralph Harmon.

Among many outstanding papers, one deserving special note was presented during the Monday Morning Session on Cinematography: F. H. Perrin's scholarly survey of "Methods of Appraising Photographic Systems." Other distinguished papers were assembled for that Session by Topic Chairman Herbert E. Behrens.

A new two-terminal semiconductor device, the tunnel diode, was described for the first time to members of our Society, on Friday morning by C. J. Gallagher, General Electric Company. This device is expected to play an important role in satellite technology.

The Program Format

A point that is not always made clear in reporting a Convention is the careful planning that goes into the arrangement of the Sessions. Once the papers are assembled by appropriate topics, the arrangement must be considered in terms of the greatest possible convenience for members who are especially interested in certain subjects or papers. For this convenience, several sessions were informally separated into Photography and Television subjects. The Photography Sessions covered Laboratory Practice (Topic Chairman was Paul A. Kaufman); Sound Recording and Reproduction (Edward Schmidt), and Instrumentation and High-Speed Photography (Charles W. Wyckoff). The Television Sessions covered International Television Equipment and Practices, and Scientific and Military Uses, with Topic Chairmen Ellis W. D'Arcy, Ralph N. Harmon and George Gordon.

The Symposium on Film Steadiness held Monday afternoon was organized by Topic Chairman Gordon A. Chambers. Two papers on color printing, "Color Matching Between Picture-Tube Phosphors and Color-Film Dyes" by Lloyd F. Hope and "Techniques in Color Duplication" by Robert O. Gale and Walter I. Kisner, were presented following the Film Steadiness presentations.

Tuesday, both morning and afternoon, was given over to the Space Technology and Image Sensing Sessions. From these sessions, eight papers are expected to be organized to appear in the January Journal. A Summary was presented at the close of these Sessions by Topic Chairman Sidney Sternberg. The convention closed with a well attended session on Video-Tape Recording on Friday afternoon.

Short Films

The motion-picture short subjects, the responsibility of John Flory and Tom Hope, were carefully chosen for aptness of subject matter and technical excellence. Among this group of entertaining and informative films, those of special interest included *Atlas—the ICBM*, produced for the U.S. Air Force by Convair. The subject of this film was especially timely and appropriate. *Assignment Jet Colorama*, a production of Informational Films, Eastman Kodak Co., was shown a second time during the week to accommodate those who were unable to attend the first showing. This film, showing jet planes on the ground and in flight, was photographed from

Edward P. Curtis, Guest Speaker at Get-Together Luncheon, and SMPTE President, Norwood L. Simmons.

Sidney Sternberg, Chairman of the Space Technology and Image Sensing Sessions, and Edgar M. Cortright, Guest Speaker at Awards Session.

various points on the ground and from another jet plane, maneuvering around the planes being photographed. The narration was especially good, conveying all the excitement of a photographer on a difficult but rewarding assignment. Another film which seemed to have a great deal of "audience appeal" was *Doctor Vishniac*, which received many favorable comments.

Equipment Papers and Demonstrations

A recent innovation that is well on the way toward becoming a tradition is the Equipment Papers and Demonstrations Session which, for this Convention, was held Wednesday Morning. Papers describing equipment on view in the Exhibit Area included "The Bell & Howell Type J Printer, Improved and Modernized," by Hans Christoph Wohlrab; "Kinoptik Lenses, Camex 8, Robot, Alpha" (Karl Heitz), by Yvonne Brandes; "Florman & Babb Triplex Animation Stand," by Arthur Florman; "Problems of Scratched Motion Picture Film" (Rapid Film Technique, Inc.), by Henry Lloyd; "Synchronous Sound Recording System for Arriflex Cameras," by Victor James; "16mm Color Processor," (Time Automated Mfg. Co.), by George Vaughn; "Punch System of Lighting Control" (Century Lighting, Inc.), by Fred M. Wolff; "Marconi Camera With VTR 1000B" (Ampex Corp.), by David J. Chapman; "A New High-Speed Color Reversal Motion Picture Film" (Eastman Kodak Co.), by E. M. Stifle; and "Cine Speed Instant Processor," by Frank J. Kelley.

This Session reflected the interest of the hundreds of viewers who daily moved through the Exhibit Area. The outstanding success of the Exhibit represents a triumph for Exhibit Chairman William J. Reddick who gave unsparingly of his time and effort during the difficult pre-Convention weeks as well as during the Convention.

As has been the case at every Convention since the happy custom of the Coffee Club began, the 86th Convention Coffee Club, sponsored by Camera Equipment Co., was the scene of many an informal get-together and meetings of old friends.

A Convention report is planned to serve three purposes; one, to inform those who could not attend of what went on, including highlights and items of special interest; two, to provide a comprehensive overall view for members who did attend; and three, to express appreciation for those who contributed their time, ideas and labor to making the Convention a success.

Putting on the Week's Program

Local Arrangements were the responsibility of R. C. Rheineck, Chairman, and E. M. Warnecke, Vice-Chairman.

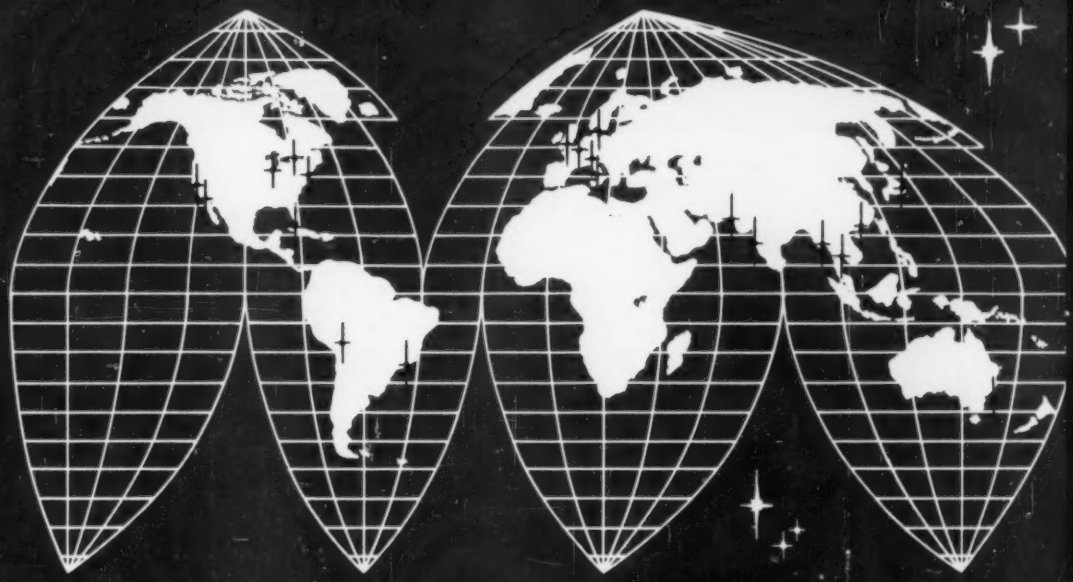
Mrs. Rheineck and Mrs. Warnecke, in charge of the Ladies Program, guided the SMPTE ladies through the program of fashion shows, luncheons and parties arranged for their delight. An unusually pleasant week was highlighted by a visit to the United Nations Building, luncheon in the Delegates Dining Room, and an informal meeting with a representative of the Delegation of Ghana, who gave an interesting insight into the work of a national delegation at the United Nations. The luncheon was arranged and sponsored by S.O.S. Cinema Supply Corp., with hostesses Mae E. Tanney and Judith Hamburger. The "Get-Acquainted" party hosted by W. J. German, Inc., was the first event in a wonderful week providing many pleasant memories for the ladies.

Passes to New York's finest motion-picture theaters were generously provided by the Capitol, Loew's State, Radio City Music Hall, Roxy, Paramount and Palace. Information, advice and a general atmosphere of friendliness was supplied by Hospitality Chairman C. W. Carpenter.

The Banquet and Dance held, according to tradition, Wednesday evening was an exceptionally gracious occasion with dreamy dance music provided by the well-known Miller tone orchestra conducted by Joie Kayne. The dance team of Norton and Patricia delighted Banquet guests with their agility and precision. The spacious Grand Ballroom was an impressive setting for an enchanted evening.

Among the key people at any Convention are those in charge of Projection and Public

Authors of five of the papers presented during the Space Technology and Image Sensing Sessions are: John B. Suomala, Jr., S. W. Spaulding, E. C. Hutter, Nancy Roman and Rudolf A. Hanel.



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HOLIDAY GREETINGS

BUON NATALE E BUON ANNO

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AVEC NOS MEILLEURS VOEUX SINCERES DE PROSPERITE POUR 1960

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OUR WARMEST WISHES FOR A JOYOUS HOLIDAY

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Address and Recording. Theirs is a heavy responsibility, in an area where things can go wrong. It is greatly to the credit of R. E. Buescher that, despite difficulties, projection and public address were well accomplished. This did not come about without the expenditure of considerable effort. At the end of the Convention, Mr. Buescher admitted that, in the words of the song, he was "A Weary, Weary Man," but he especially requested that recognition be given his helpers who turned deaf ears to the "quitting whistle" and managed to be around when needed. Among them were: Jim Cornell of General Electric; Jack Greenfield of Naval Photo Center; Don Johnston of Charter Oak Films; and Jack Leahy and Alfred Ulmer, both of RCA. Equipment was contributed by Capitol Motion Picture Supply, Florman & Babb, Radio Corp. of America, S.O.S. Cinema Supply and United Camera Co.

The man in charge of Hotel Arrangements frequently finds himself bent and bowed under a mountain of details and beset with complaints from practically everybody. This assignment was effectively carried out by B. F. Perry.

W. H. Metzger accepted the double task of Registration Chairman and Auditor and wore both hats with ease and aplomb. Publicity was in the capable hands of Charles Austin. Membership Chairman J. T. Dougherty was assisted by Robert E. Burns and they helped a large number of registrants to apply for membership. Arthur J. Miller was in charge of arrangements for the Get-Together Luncheon and Saul Jeffee was in charge of Banquet arrangements.

C. F. Lo Balbo was in charge of Transportation; and Administrative Assistants V. J. Duke, J. W. Kaylor, M. Peter Keane and J. L. Koushouris contributed ably to the success of the Convention.

Presentation of Awards

The Awards Session is always a special occasion and the organization of it this year benefited from the co-chairmanship of C. J. Hirsch and Ed Warnecke. The guest speaker was Edgar M. Cortright, Chief, Advanced Technology Program, National Aeronautics Space Administration. His illustrated lecture was very enthusiastically appreciated. It is being prepared for publication in January.

The awards citations and abstracts of the introductions are published below.

Society Awards

A special session for the presentation of awards was held on October 6 in the evening in the Skytop Room, with President Norwood L. Simmons presiding.

Norwood Simmons and John C. Stormont, recipient of Student Member Award.

A Student Member Award was made, the first by the Society which established the Award in 1957. It was made to John C. Stormont, at present in his Senior year at the University of Miami. The award was for his paper "Student-Built 16mm Continuous Positive Film Processor as Used in University Film Productions," presented before the Miami Student Chapter in April 1959 and at the Society's Miami Beach Convention in May. It is published in the October 1959 *Journal*, pp. 690–693.

Mr. Stormont is majoring in motion pictures in the Radio-Television and Film Department of the University of Miami, and is working toward a Bachelor's Degree in communications.

The Student Member Award was created to afford special recognition to those Society Members who are today preparing themselves for positions in the motion-picture and television field.

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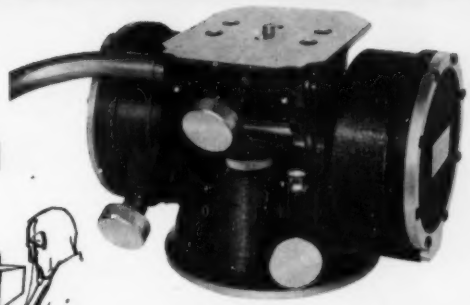

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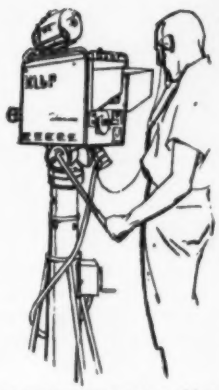

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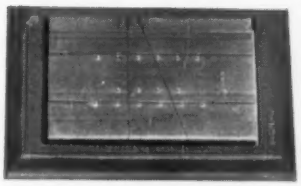

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	per roll
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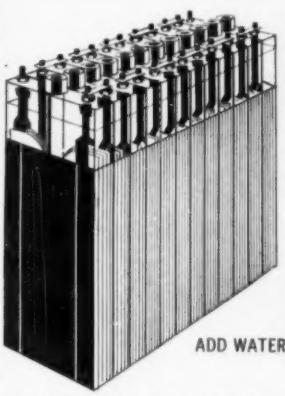

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Standing between SMPTE President Norwood Simmons and Past-President Barton Kreuzer are seven recipients of the Society's Fellowship Award and the wife of one recipient, who accepted in behalf of her husband. They are: Paul W. Vittum, James W. Kaylor, Robert E. Birr, Walter E. Beyer, Mrs. Henry Ushijima, Philip E. Smith, Julian H. Webb, and Hans C. Wohlrab.

Fellows

The following members were raised to the rank of Fellow, Certificates were presented by Barton Kreuzer, Past-President of the Society:

Walter E. Beyer
Robert E. Birr
Harry P. Brueggemann
John M. Calhoun
Albert Gillet
Robert Gottschalk
C. Loren Graham
James W. Kaylor
G. Don Malkames
Leon C. Shelly
Philip E. Smith
Henry Ushijima
Paul Vittum
Julian H. Webb
Hans C. Wohlrab

Honorary Member

The Award of Honorary Membership was bestowed upon Harvey Fletcher. The citation, prepared by the Honorary Membership Committee under the Chairmanship of Charles R. Fordyce, states: The evolving technology of the motion picture and television industry continues to profit from the contributions of Harvey Fletcher. He is one of those rare individuals whose understanding ranges both broadly and deeply. As a pioneer in modern psychoacoustics, he bridged that forbidding chasm between physics and psychology leaving such permanent spans as the relation between frequency, intensity, and loudness (the Fletcher-Munson curves), the subjective loudness (sone) scale, and the concepts of masking. The auditory nervous system attracted his attention and led him to formulate in 1930 his "Space-Time Pattern Theory of Hearing." The notions expressed therein still form the backbone of research thinking in auditory theory. He made basic contributions toward integrating phonetic analysis, speech production, and the acoustical properties of speech.

As important as these milestones are in human communication, he was not, as modern intellectuals often are, content to leave them to be exploited by others. Despite his stature among basic scientists, he was not encumbered by a disdain for the practical. Thus he used his intuition to solve problems of the real world. He was one of the early physical scientists to influence the field of medical acoustics, publishing such works as "Physical Meas-

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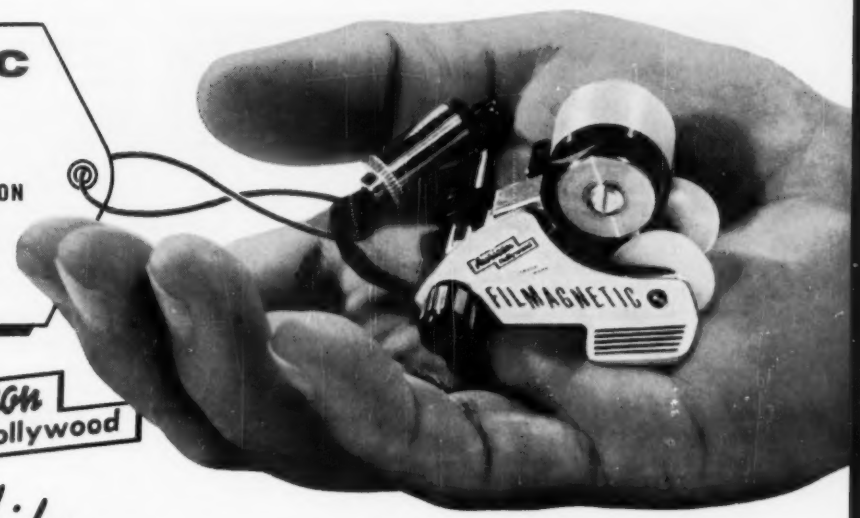

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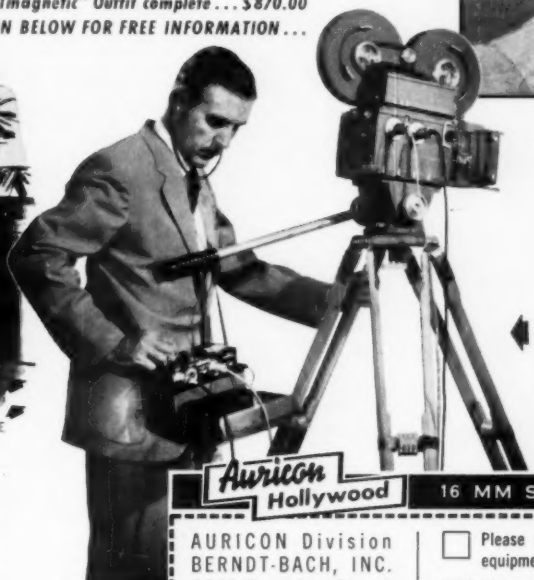

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urement of Audition," "Measuring Children's Hearing," and "Can We Scientifically Advise Patients as to the Effectiveness of Hearing Aids?" He established the first effective methods for intelligibility testing of communication systems, and thought clearly about the complex problems of sound reproduction. In 1924, he published with W. H. Martin "High Quality Transmission and Reproduction of Speech and Music" outlining those factors which both to industry and the "hi-fi" fraternity have become standard terms of reference. He went further in his subsequent works described in "Hearing, the Determining Factor of High-Fidelity Transmission," and "Auditory Perspective." In the latter paper, he proposed a sound reproduction system to convey spatial as well as tonal information. Thus he sired the current development of stereophony. He arranged the first demonstration of stereophonic transmission of music between Philadelphia and Washington in 1933, and in 1941 published in the *Journal of the Society of Motion Picture Engineers* an account of a "Stereophonic Sound Film System."

Harvey Fletcher was born in 1884 at Provo, Utah, attended Brigham Young University and received his PhD degree in Physics from the University of Chicago. From 1911–1916 he was Head of the Department of Physics at Brigham Young and in 1916 joined the Bell Telephone Laboratories. He retired from that organization in 1949 as Director of Physical Research, and joined Columbia University where he established a new Acoustics Laboratory. He is presently Director of Research and Dean at Brigham Young University. The honors bestowed on him by his admirers are legion. Among them are five honorary doctorate degrees, the Louis Edward Levy Gold Medal of the Franklin Institute, the Progress Medal of the SMPTE, and the Gold Medal of the Acoustical Society of America. He is a member of the National Research Council and the National Academy of Sciences. He served as Chief of the Acoustics Section of NDRC during World War II, as President of the American Society for the Hard of Hearing, President of the Acoustical Society of America, Vice-President of the American Association for the Advancement of Science, and as President of the American Physical Society.

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Journal Award

The Journal Award for 1959 was presented to Derwyn M. Severy for his paper on "Photographic Instrumentation for Collision Injury Research." Three other papers were chosen for Honorable Mention. The papers and authors are:

D. W. Fassett, F. J. Kolb and E. M. Weigel, "Practical Film Cleaning for Safety and Effectiveness"

Otto H. Schade, Sr., "On the Quality of Color Television Images and Perception of Color Detail"

Donald A. Delwiche, James D. Clifford and William R. Weller, "Printing Motion-Picture Films Immersed in a Liquid—Part II: Evaluation of Liquids"

In the citation accompanying the Journal Award, read by James L. Wassell, Chairman of the Journal Award Committee, the author's many activities and accomplishments were noted. The following is quoted from the citation:

"In this paper, which appeared in the February issue of the *Journal*, Mr. Severy describes in detail the photographic instrumentation required during research studies conducted at the University of California. The Award Committee was impressed by the clarity with which this subject was presented. Mr. Severy's paper provides guide posts for the complete photographic coverage of similar future research projects.

Mr. Severy has concentrated primarily on the engineering field in his work at the Institute of Transportation and Traffic Engineering, University of California. He has, at the same time, achieved an impressive military background as a commanding officer in several naval aviation posts.

Herbert T. Kalmus Gold Medal

Herman H. Duerr was awarded the Herbert T. Kalmus Gold Medal for his contributions to the development of color films and color film processes. The citation, prepared by the Herbert T. Kalmus Gold Medal Award Committee was read by the Chairman, W. E. Gephart.

Dr. Herman H. Duerr is Technical Director of the Ansco Corp., where he is in charge of research and development. He came to the United States in 1931 from Germany where he had received a doctor's degree in chemistry and had been working for the I. G. Farben Industrie—in the field of color film and dye chemistry research before being transferred to the U.S.A. He has since been associated with the Ansco Corp. in Binghamton, N.Y.

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ucts, Dr. Duerr has been largely responsible for much of the color film development program at Ansco. He did much of the early work at Ansco on dye couplers and dyes as color sensitizing agents. He has done considerable work and published various papers in the field of color sensitometry. He has published a number of papers in the *Journal* and elsewhere on Ansco color films and particularly on Super-Anscochrome reversal films. He nas served the Society as the dynamic head of the Color Committee during a most important era.

Dr. Duerr has been awarded many patents in the color film field and has generally contributed a great deal to the development of color films and color film processes.

David Sarnoff Gold Medal

W. R. G. Baker was awarded the David Sarnoff Gold Medal for his outstanding work as Chairman of the National Television System Committee. Dr. Baker was unable to be present so the Award was accepted on his behalf by Alfred N. Goldsmith. The citation, prepared by the David Sarnoff Award Committee, was read by the Chairman, Frank N. Gillette.

Dr. Walter R. G. Baker received the degree of Bachelor of Science in Engineering in 1916, that of Master of Science in Electrical Engineering in 1918, both from Union College. He has received honorary doctorate degrees from Union College in 1935, Syracuse University in 1951 and Brooklyn Polytechnic Institute in 1955.

In 1917 he joined General Electric as design engineer in charge of transmitters. In 1930 he went to Radio Corp. of America to head the radio activities of the new organization. There he progressed to Vice-President in charge of engineering, then both engineering and manufacturing, and finally Vice-President and General Manager. In 1935 he returned to GE, was made a Vice-President in 1941 with responsibility for all of GE's electronic activity, became a consultant to the executive office in 1956. He retired from GE November 30, 1957, and immediately became President of Syracuse University Research Corporation.

Dr. Baker has been actively associated with literally dozens of technical societies and industry associations and has held many of the highest offices in such groups. To mention only a few, he was variously director, treasurer and in 1947 President of the Institute of Radio Engineers. He was President of the Electronic Industries Association in 1957 and has been Director of the EIA Engineering Department for some 25 years.

We honor Dr. Baker at this time for his outstanding work as Chairman of the National Television System Committee which functioned on two separate occasions when standards were urgently needed to promote the growth of television in the United States.

In these efforts the best engineering talent in the industry was formed into one gigantic organization devoted solely to the task of developing the standards required, in the first instance for monochrome television and in the second for color television.

Each effort followed a period of intensive but uncoordinated development on the part of many highly competitive companies. While all workers could agree on some things there were many points upon which contradictory views were firmly held and vigorously advanced.

Considered against this background, the NTSC achievement in arriving at standards supported by the entire industry (doing so for black-and-white TV in an astounding six-month period) is all the more impressive. Dr. Baker contributed personally to this success

(1) by helping to develop the idea of an NTSC:

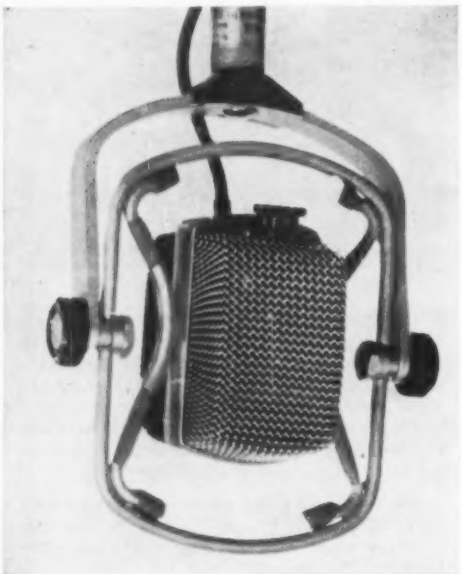
(2) by setting up the committee organization and securing the active participation of dozens of companies and hundreds of individuals, and

(3) by guiding and directing the work in a manner which promoted accomplishment and brought about compromise at many points of very serious conflict.

Although others, many others, contributed to NTSC, Dr. Baker's share was a vital one for which he richly deserves the measure of recognition afforded by the David Sarnoff Gold Medal Award.

Samuel L. Warner Memorial Award

The Samuel L. Warner Memorial Gold Medal for 1959 was presented to Dr. John G. Frayne for his contribution in engineering a 70mm stereo six-track magnetic film system and test films. The citation, pre-



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pared by the Samuel L. Warner Award Committee, was read by the Chairman, John Aalberg.

A special committee for the Samuel L. Warner Award is responsible for reviewing the inventions or methods most likely to have a beneficial effect on the recording and reproduction of sound and picture and selecting the engineer who has made the outstanding contribution.

Dr. Frayne has been working continuously in sound motion-picture engineering since 1928. His contributions span the technology of sound motion pictures from light valves and noise reduction to 70mm magnetic film recording and reproducing systems. The committee was unanimous in its opinion that Dr. Frayne's contribution in engineering a 70mm stereo six-track magnetic film system and test films therefore met the rigid requirements for this award.

In addition to these contributions, Dr. Frayne has influenced sound recording by sponsoring various educational programs, as co-author of a text book on sound and as a friend to those of us who work in his field.

Progress Medal

The Progress Award for 1959 was presented to Harold E. Edgerton. At the time of the Convention Dr. Edgerton was in Puerto Rico on a deep sea expedition. The Progress Medal was accepted on his behalf by Charles Wyckoff. The following citation, prepared by the Progress Medal Award Committee was read by the Chairman, Dr. Deane R. White.

Harold Eugene Edgerton received his undergraduate training at the University of Nebraska in 1925 and Master and Doctor of Science Degrees at the Massachusetts Institute of Technology where he has been a Professor of Electrical Engineering since 1926.

Professor Edgerton has pioneered with spectacular success in the fields of high-speed photography and stroboscopy. His researches in these fields have been reported in our Society's publications frequently since 1931. He has contributed to the development of short-duration high-intensity light sources, to the design of equipment to be used with them and finally to many important, as well as popular, applications thereof. We have all seen examples such as stop-motion photography of high-speed machinery or even a golf swing, beautiful photographs in the National Geographic Magazine taken several miles below the surface of the seas and awesome pictures taken during various phases of atomic explosions. A visit to Professor Edgerton's laboratory is a delightful experience in informality and a stimulating introduction to his many and varied interests.

Professor Edgerton has performed in many capacities in the service of our Government, as well as in the interests of various technical societies. He has been very active in the high-speed photographic activities of our Society and has served as its representative at both the 3rd and 4th International Congresses on High-Speed Photography. Also he finds time to serve as Chairman of the Board of the successful firm of Edgerton, Germeshausen and Grier, Inc., which he helped to found. His talents have been widely recognized by the following awards: the Progress Medal of the Royal Photographic Society of London, the Modern Pioneer Award of the National Association of Manufacturers, the Potts Medal of the Franklin Institute, the National Geographic Society's Burr Prize, the Sprague Memorial Award from the National Press Photographer's Association and designation as the New England Engineer for 1958 by the Engineering Society of New England.

He is a Fellow of our Society, of the American Institute of Electrical Engineers and the Photographic Society of America.

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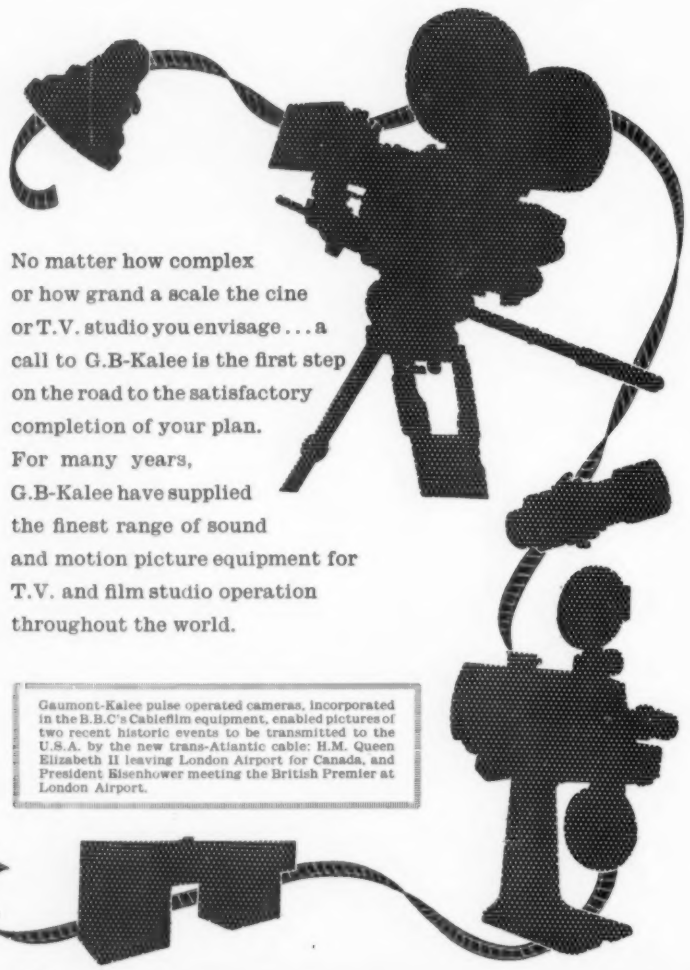

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Gaumont-Kalee pulse operated cameras, incorporated in the B.B.C.'s Cablefilm equipment, enabled pictures of two recent historic events to be transmitted to the U.S.A. by the new trans-Atlantic cable: H.M. Queen Elizabeth II leaving London Airport for Canada, and President Eisenhower meeting the British Premier at London Airport.

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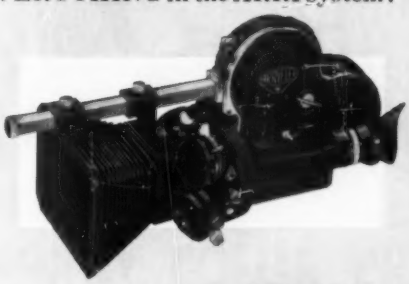

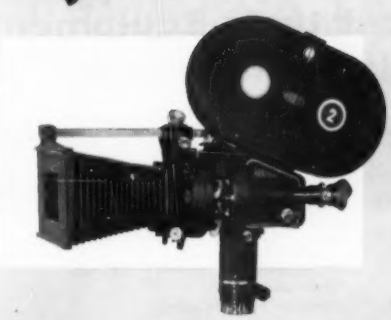

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Education, Industry News

The American Science Film Assn. is being formed by an ad hoc committee, according to an announcement by Randall M. Whaley, Associate Dean of the School of Science Education and Humanities at Purdue University. Dr. Whaley is Chairman of the ad hoc committee. The two Vice-Chairmen are A. B. Garrett, Ohio State Univ.; and Carl Allendoerfer, Univ. of Washington. Treasurer is Donald G. Williams, Syracuse Univ.; and Secretary is Robert E. Green, National Academy of Sciences — National Research Council. Committee members are: John Flory, O. S. Knudsen, Richard H. Orr, Daniel Rochford, Edwin W. Roedder, H. Burr Roney, Robert Wagner and Willard Webb. It is expected that formal organization of the American Scientific Film Association will be completed in 1960.

Proceedings of the 14th Session of the International Commission on Illumination (*Jour.*, July p. 494) will be published early in 1960 and will include papers, discussions and technical Recommendations. Recommendations in the following six categories were tentatively approved and are scheduled to become effective six months from the date of tentative approval if no objections have been raised by any National Committee: Measurement of Light; Colorimetry; Photopic and Scotopic Vision; Sources of Visible Radiation; Mine Lighting; Lighting for Transport Other Than Automobile and Air. Information about publication of the Proceedings or the Recommendations is available from L. E. Barbrow, Secretary of the U.S. National Committee, C.I.E., National Bureau of Standards, Washington 25, D.C.

Two television stations in West Nigeria are scheduled to begin operation late in 1959. Located at Ibadan and Abafon, the stations will provide the first permanent television service in Africa. At Ibadan, the station will be equipped with a 500-w vision transmitter feeding into a three-stack super-turnstile aerial. The Abafon station will have a 5-kw transmitter and will cover the towns of Lagos, Abeokuta and Ijebu Ode. Studio equipment is supplied by Marconi Wireless Telegraph Co.

Electrical Measurements on Photographic Emulsion Grains is the subject of the 2000th scientific paper from the Research Laboratories of Eastman Kodak Co. The paper, by John F. Hamilton and L. E. Brady of the physics division of the laboratories has been accepted for publication in the *Journal of Applied Physics*. It concerns a new technique for exposure of a single, tiny silver bromide crystal to an electrical field and to an anazingly brief flash of light — one ten-millionth of a second.

Papers from the Kodak Research Laboratories are numbered consecutively and have appeared in 201 scientific journals throughout the world. The first of this series of papers was published in 1913 in the *Philosophical Magazine* of London. It discussed the absorption of light in materials such as photographic emulsions, glass, and other media.

An English-language version of the Russian magazine *Optics and Spectroscopy* is translated and published semi-monthly by the Optical Society of America. The project receives assistance from a grant-in-aid from the National Science Foundation. Subscriptions (except for special rates to OSA members) are available at $25.00 a year from the Optical Society of America, Inc., 33 University Road, Cambridge 38, Mass. Foreign subscriptions are $28.00 yearly.

Also reflecting current interest in U.S.S.R. scientific publications is an announcement from the American Institute of Physics, 335 E. 45 St., New York 17, that English-language versions of eight leading Soviet physics journals are available five to seven months after initial publication.

The Third International Industrial and Labour Film Festival will be held in Belgium in March 1960 under the auspices of the Ministry of Labour. Films accepted for showing must be in one of five categories: industrial research; training or instructional; industrial or technical information; human labor problems, and productivity and rationalization. Only films made since January 1956 will be considered. Further information is available from La Cinémathèque de Belgique, Palais des Beaux-Arts 23, Ravenstein, Brussels, Belgium.

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section reports

The Canadian and Rochester Sections held a joint meeting on October 24 at the Royal York Hotel in Toronto, with approximately 70 members and guests present.

E. S. Purrington, Manager, Photographic Dept., Ford Motor Co., opened the meeting with a discussion of "Ford Motor Company-Film Production and Utilization," during which he outlined the uses to which the motion picture is put at the Ford Company. He showed a demonstration reel of its use in engineering, research, public relations, advertising and training.

Maurice Mitchell, President of Encyclopedia Britannia Films, in a discussion of the "Impact of Technology on Education," described the state of education in the United States and Canada. He compared the educational systems of Russia and the United States, pointed out various shortcomings, and offered suggestions for their improvements.

N. Rainger of the British Broadcasting Corporation Research Department, London, England, presented a paper on "Cable Film Equipment." He described its development and uses to date. The equipment is intended for the transmission of short lengths of 16mm news film over a programme channel in very long cables or ration link systems. The time of transmission is 100 times the normal running time of the film.

After the meeting the members, guests and wives gathered for cocktails and a roast beef dinner.—Ronald E. Ringler, *Secretary-Treasurer*, Canadian Section, 85 Eglinton Ave., E., Toronto, Ont., Canada.

The Hollywood Section met on October 20 at the ABC Studio in Hollywood with as attendance of 125. The speakers were: W. W. Gordy, RCA Service Co., North Hollywood, who discussed the "Role of Motion Picture and Television in the Training of Missile Support Personnel"; Jack Fort, RCA Defense Electronics Products, W. Los Angeles, whose topic was "The RCA Micro-Modular Concept"; and Walter Beyer, Motion Picture Research Council, Hollywood, who delivered a "Summarizing Report on the Research Council Theater Liaison Program."

The 16mm color film "Atlas on Target" supplied by Mr. Gordy was most interesting. Made by Convair, it depicted the staging and launching of an Atlas missile, giving particular emphasis to the elaborate communication and instrumentation techniques employed along the entire missile range.—Ralph E. Lovell, *Member, Board of Managers*, 2554 Prosser Ave., Los Angeles 64, Calif.

The New York Section met on November 4 at the World Affairs Center Auditorium with an attendance of 80. CWO Richard R. Conger, USN, former Photographic Officer in charge of Admiral Dufek's Polar Expedition during the International Geophysical Year, addressed the group. His subject was "Motion Picture Photography at the South Pole."

The audience attentively followed CWO Conger's account of his experiences while participating in "Operation Deep-Freeze" and his description of problems encountered with the operation of motion-picture equipment under temperatures as low as −78 F.

Of particular interest to Society members were CWO Conger's remarks pertaining to the behavior of petroleum and graphite lubricants at temperatures lower than −40 F. At this temperature, these materials assumed the characteristics of abrasives rather than lubricants. However, the problems were solved with diester liquid lubricants replacing petroleum products and molybdenite replacing graphite. Similarly, neoprene pulley belts proved satisfactory and replaced rubber and leather belts driving motion-picture cameras.

CWO Conger suggested that anyone having specific questions or requiring details pertaining to his experiences at the South Pole should feel free to write directly to him at Pensacola. Edward M. Warnecke, *Secretary-Treasurer*, Eastman Kodak Co., 342 Madison Ave., New York, N.Y.

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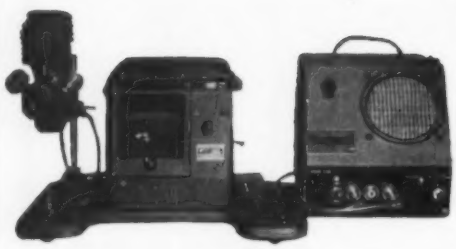

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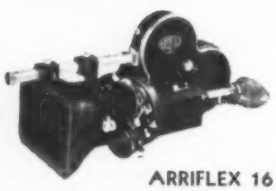

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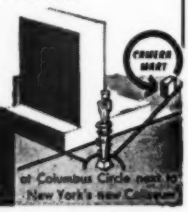

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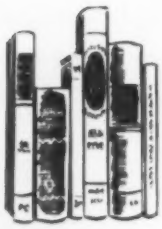

books revlewed

Junction Transistor Electronics

By Richard B. Hurley. Published (1958) by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16. 6 by 9-in., 473 pp + vi-xvii, Price $12.50.

The present-day importance of the transistor is well known, and is reflected by the number of books available on practically all phases of transistor technology. As its title implies, this book deals exclusively with the junction transistor, and is intended for the practicing engineer with a background in electronics. In accordance with this intent, the treatment of the internal physics of semiconductors is limited to the first chapter. Chapters 2 through 7 are devoted to a discussion of low-level considerations, including the development of equivalent circuits, audio-frequency amplifiers, biasing, noise, and degenerative feedback. The author makes use of the "r" parameters, in contrast to the more commonly found "h" parameters; however, the necessary conversion formulas for the r, h, and y parameters are given, and with care in interpretation, the reader should not experience any difficulty. Chapter 6, dealing with noise considerations, is notable because of the brief but thorough (to a practicing engineer) treatment.

Following the treatment of low-level considerations, eleven chapters, approximately one-half of the book, are devoted to high-level situations, including physical considerations, power amplifiers, d-c amplifiers, d-c regulators, high-frequency equivalent circuits, internal feedback, video amplifiers, tuned amplifiers, gain control, oscillators, and modulation circuits. The chapters on high-frequency equivalent circuits and video amplifiers are particularly well thought out, and although such information can be obtained from other sources, few books contain a detailed treatment of these extremely important topics.

The final four chapters are devoted to a discussion of switching circuits. The engineer dealing with computers or data-processing devices will undoubtedly complain that this treatment is far too brief, especially since a short introduction to Boolean algebra is also given in this part of the book. However, the treatment is sufficient to give the reader a general introduction to switching circuits, and the excellent bibliography included at the end of each chapter is a source of more detailed information.

As with any book in a constantly expanding broad field such as transistors, this book represents a compromise. As the author states in the preface, it is not intended as a handbook, but rather as an aid to practicing engineers interested in transistors, and, more particularly, in junction transistors, and their applications. In this respect, the exclusion of more modern high-frequency devices such as the field-effect transistors limits the value of the book to some extent, and the fairly advanced mathematics used in a number of places places a severe limitation on its value to technicians. However, for the engineer experienced in electron tube technology, the book provides a very good introduction to junction transistors and their applications. In the field of television, the use of transistors in both transmitting and receiving equipment is rapidly expanding, and Mr. Hurley's book would be a good text for the practicing engineer interested in broadening his knowledge. It is of less value in the motion-picture field, although junction transistors are being used both in audio

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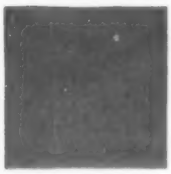

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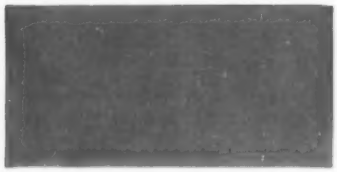

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equipment and in process control equipment.

In summary, the book fulfills its stated objective — that of explaining the junction transistor, its characteristics, and its applications — in a manner familiar to the practicing engineer, and is therefore a useful and interesting addition to the field.—*Harvey W. Mertz*, 406 Cornwall Rd., Haddonfield, N.J.

(*Ed. Note:* Mr. Hurley presented a paper on the Transistor Session at the Los Angeles Convention in 1956; "The role of transistors in electronics," *Journal*, June 1957, pp. 330-332.)

Television Advertising

By Clark M. Agnew and Neil O'Brien. Published (1958) by McGraw-Hill Book Co., 330 W. 42 St., New York 36. 300 pp. Illus. 6⅜ by 9¼-in. Price $9.50.

Those who have been in television advertising from the start may have forgotten the many long hours of trial-and-error learning, and the many different fields they have had to master, before reaching their present level of proficiency. Newcomers to this young and still expanding field can probably best appreciate the vast scope of the subject matter that is now required for professional status. A field so large and of such rapid growth as this one has needed a book to document it in its present state. The authors have done an excellent job of meeting this need.

The many subjects covered in the main section of the book may be broadly divided into theory, production basics, production practice, production particulars, and planning for the future. Following this, about 50 pages are devoted to an advertising dictionary, and to an appendix of unusually high value as a source of factual reference material.

It is difficult to convey adequately in a necessarily brief review the thoroughness with which the authors have developed their subject. In studying the sponsor, the authors examine the pressures which influence him in his important responsibility of accepting or rejecting material. In studying the audience, they make it quite clear that any viewer can turn off the sound or go out for a snack during the commercial. They compare the faults, as well as the virtues, of audience sampling methods. They demonstrate "gobos," "split-gobos" and other production particulars. These and many more pieces of the entire subject are presented in a very readable manner.

Novices will find this book useful; So will experienced professionals, if only as a welcome refresher course.—*Don G. Malkames*, 7 Plymouth Ave., Tuckahoe, N.Y.

A Grammar of the Film

By Raymond Spottiswoode. Paperbound ed. published (1959) by University of California Press, Berkeley 4, Calif. 328 pp. including index, Preface and Introduction. 4 by 7-in. Price $1.50.

It is good news indeed that Raymond Spottiswoode's *A Grammar of the Film* has been published in a paperbound

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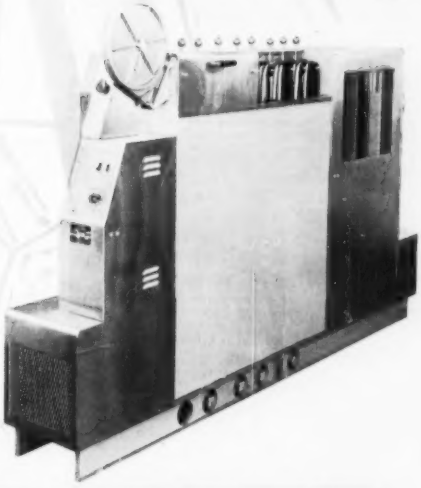

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edition. Originally published in 1935 by Faber, and Faber Ltd., of Great Britain, it was published in the United States in 1950 by the University of California Press (publishers also of the present reprint).

Although by no means the equal in practical ways of Spottiswoode's classic, *Film and Its Techniques, A Grammar of the Film* has considerably more than historical interest. The book repays careful reading, and if certain sections seem intensely and exclusively concerned with "battles long ago," and in other sections the youthful author seems more erudite than lucid, even these sections will repay careful reading for occasional flashes of insight and stimulating (and controversial) argument.

This book was written with high aims and lofty purposes, ". . . to make as precise as possible the language and grammar which the film, as a prospective art-form, has to acquire; next to outline its history, redressing the balance of criticism which has inevitably but wrongly laid sole stress on the machine-made film, and indicating the economic and political factors which have determined its course in the past and are likely to influence it in the future. . . ."

One of the most charming sections of the book is the preface (to the 1950 edition), written by the mature author of *Film and Its Techniques*, in which he evaluates the work of the young author with perception and objectivity.

"With all the heady enthusiasm of his twenty years and unembarrassed by any actual contact with film, he felt that he had the answer," says the older man of the younger with perhaps a half-amused, half-regretful sigh for that vanished enthusiasm.

"How then, does this early study of film stand up to the passage of time?" the older man inquires. "The answer seems to be," he says, "that film is a medium still so much under commercial domination that it is always in danger of falling into stereotyped forms which are easy to exploit. There is, therefore, a continuing need to go back to fundamentals, and see what new forms can be spun out of the basic substance of film. Never was the need for experiment greater than today, when so little is being done. Thus any study, however imperfect, which tries to lay bare the scaffolding of the film medium, may be able to help the creative worker on his way."

It is a pity that the entire Preface cannot be quoted here in its entirety. It is witty and delightful and at the same time full of sound observations and critical evaluations. The author (of the Preface) has no hesitancy in pointing out the imperfections of the young author's book, which he exposes with a devastating wit. It is with something akin to a shock of recognition that the reader realizes that the older author is the same person as the younger author who has developed with the years and brilliantly fulfilled the promise of his early efforts.

Science Study Series, prepared under the direction of the Physical Science Study Committee of Educational Services Inc., Watertown, Mass., published in coopera-

tion with Doubleday-Anchor Books, New York, and Wesleyan University Press Inc., Columbus, Ohio, 1959, 4¼ by 7¼-in., illus., 95¢ each.

S1, *The Neutron Story*, Donald J. Hughes, 158 pp.
S2, *Magnets, The Education of a Physicist*, Francis Bitter, 155 pp.
S3, *Soap Bubbles and the Forces which Mould Them*, C. V. Boys, 156 pp.
S4, *Echoes of Bats and Men*, Donald R. Griffin, 156 pp.
S5, *How Old Is the Earth?* Patrick M. Hurley, 160 pp.

The Science Study Series, which has begun with the publication of the five titles listed above, is one result of the research, directed by the Physical Science Study Committee, which was aimed at a major revision of the teaching and study of physics. The PSSC was formed at the Massachusetts Institute of Technology in 1956 by a group of 200 high-school teachers, editors, authors, journalists, apparatus-designers, film producers and other specialists. The PSSC is currently completing a new physics text book, producing a library of short classroom films, and designing simple apparatus that can be constructed by teachers and students.

The Science Study Series, which will eventually number more than seventy illustrated paperback books, will be issued at the rate of about fifteen titles a year. Some will tell of the role of physics in the world of man, his technology and civilization. Others are biological in nature. According to the statement at the beginning of each book, "the primary purpose of these books is to provide an authoritative survey of physics within the grasp of the young student or the layman." It is stated that "all the authors have been selected for expertness in the fields they discuss and for ability to communicate their special knowledge and their own views in an interesting way."

Donald J. Hughes, who wrote *The Neutron Story*, learned the story from Enrico Fermi, and was invited by Mme. Fermi, a member of the PSSC, to contribute this opening monograph.

Magnets, the Education of a Physicist used the pedagogical technique recommended by James B. Conant, that of leading the student through the maize of learning already followed by the pathfinder.

Soap Bubbles and the Forces Which Mould Them is a reprint of a classic of science literature, out of print since 1916. As a model of lucid exposition, it has much to recommend it to science authors and report writers, except that it is unindexed, the only one among the first five in the series to show such a conspicuous lack!

Echoes of Bats and Men is written by the man who, in 1938, first heard the ultrasonic voices of bats. Donald R. Griffin has united biology and physics, the two sciences with which the *Science Study Series* is concerned, in this report on studies of bats, porpoises, and whirligig beetles, and of electronic radar and sonar.

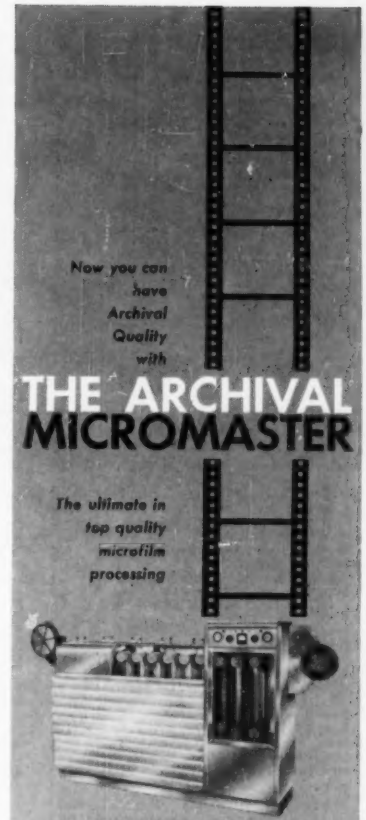
Patrick M. Hurley discusses the search for the answer to the question *How Old Is the Earth?* in the light of our new knowledge of radioactivity, treating radioactivity both as a source of energy and as a dating tool.

Next on the list are to be *The Physics of Television*, subtitled *Electrons, the Eye and the Ear*, by Donald G. Fink, Director of Research, Philco Corp.; and *Crystals and Crystal Growing*, subtitled *Order in Nature*, by Alan Holden and Phylis Singer.

Obviously not for professional scientists, *The Science Study Series* books may be useful in filling in gaps in the specialist's knowledge. Although they vary, it may be said that, in general, the books represent the same type of "tutorial" material that one finds in some magazine articles, though some of the books may go deeper or cover subjects more fully. For example, *Echoes of Bats and Men* has been treated in current periodicals, but here the material is presented soundly and in extremely useful format for study and ready reference.

The First Year of Title VII, an article by Kenneth D. Norberg and Thomas D. Clemens in the Fall 1959 issue of *Audio Visual Communication Review*, presents an informative report of considerable value for engineers as well as to the educators. "A Report on the Administration of Educational Film Activities in 14 Countries," a survey by the International Council for Educational Films for Unesco, also presents relevant facts and draws clear-cut conclusions. The three main articles of the issue ("New Directions for Communication Research," by L. P. Greenhill; "Comparative Costs for Televised and Conventional Instruction," by W. F. Siebert; and "Education and the Challenge of Mass Culture," by George Gerbner), although different in subject matter, all seem to fall a little short of the exhaustive and scholarly treatment that would result in an important contribution to a special and limited field and also to fall short of the condensation of material and clarity of style that would appeal to the average reader. This is not to say that there is not much of value in each of these three articles. Each deals with an important facet of the broad area of audiovisual communication and each contains many thought-provoking statements. Perhaps the common fault — if there be one — lies in some uncertainty as to the point of view, or rather as to what type of reader is to be reached: the specialist, to whom a special vocabulary and an academic style would present no barriers to understanding, or the average reader looking for information presented clearly and concisely.

Job information for experienced engineers and scientists is contained in the Fall 1959 issue of *Careers*, a publication which gives a brief run-down of job opportunities in the big companies. It is published by Careers, Inc., 15 W. 54 St., New York 36. The publishers note that free distribution is normally limited to alumni of ECPD-accredited colleges and universities through their alumni placement offices or other accredited agencies. It is noted that "Popular-priced edition is made available to all others by Simon and Schuster, Rockefeller Center, New York."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New Members

The next *Directory for Members* is planned for April 1960. The following members have been added to the Society's rolls since the list published in Aug. 1959. Also listed are those regretfully reported as deceased since that date. The designations of grades are the same as those used in the *Directory*. An up-to-date list of the Sustaining Members appears on the outside back cover of each month's *Journal*.

Fellow (F) Active (M) Associate (A) Student (S)

Deceased

John W. Boyle (F)
Dr. J. C. Burnett (F)
Charles Fermaglich (M)
W. G. Millais (M)
A. J. Moran (A)
W. J. Morlock (M)
Franz Netschert (A)
Brand D. Ochse (M)
Sydney M. Robinson (A)
M. G. Sinkewitch (A)
George H. Walter (M)
Joseph Weiss (A)
Merrill G. White (M)

Abdel-Akher, Mohamed Mostafa, Deputy Chief Eng., U.A.R. Broadcasting, Abu-Zaabal, Cairo, Egypt, U.A.R. (M)
Adison, John C., Chief Eng., WPCA-TV. Mail: 426 Haywood Rd., Ambler, Pa. (A)
Albano, Dave L., Univ. Miami. Mail: 1250 Walsh Ave., Apt. E, Coral Gables, Fla. (S)
Ali, Farouk Ibrahim, Dir. of Tech. Office, U.A.R. Broadcasting, Eng. Dept., 4 Sheriffein St., Cairo, Egypt, U.A.R. (M)
Artus, Lowell R., Eng. Coordinator, KELO-TV, 13 St. & Phillips, Sioux Falls, S. D. (A)
Avellana, Angel, Mot.-Pic. Sound Eng., National Motion-Picture Production Center, Program Support, USOM/Vietnam, Saigon-Vietnam, P. I. (A)

Babletek, Jenoe L., Elect. Eng., Waisman-Ross & Assoc. Mail: 110 Inkster Blvd., Winnipeg 4, Manit., Can. (M)
Baillie, Howard, General Mgr., George Humphries & Co. Labs. Mail: "Gorsecroft," Templewood La., Farnham Common, Bucks., Eng. (M)
Banks, Dick LeRoy, Rochester Inst. Tech. Mail: 452 Linden Ave., Rochester 10, N. Y. (S)
Bateman, Richard C., SKY-VUE DI Theatre, Shaw AFB. Mail: 115 Andorson St., Sumter, S. C. (A)
Baumgardner, George W., Rochester Inst. Tech. Mail: 84 Adams St., Rochester 8, N. Y. (S)
Bayoglu, Yavuz, Grad. Student of Engr., Murat Film, Turkey. Mail: Box 2340, Georgia Institute of Technology, Atlanta 13, Ga.(A)
Baysal, Kemal, Owner, Baysal Films, Taksim Saray, Istanbul, Turkey. (M)
Bechly, Fred L., Eng., Radio Corp. of America. Mail: 418 Garden State Dr., Merchantville, N. J. (A)
Benone, Adolph H., Film Editor, ABC-TV. Mail: 7120 Samoa Pl., Tujunga, Calif. (A)
Benrios, George, Camera Techn., Florman & Babb. Mail: 1660 Nelson Ave., New York 53. (A)
Benson, K. Blair, Sr. Project Eng., CBS Television. Mail: Harbor View, South Norwalk, Conn. (M)
Blasingame, James B., Box 9057, University of Miami, Coral Gables 46, Fla. (S)
Boeniger, Kene, Cameraman-Producer, Alexath & Boeniger Film Ltd. Mail: Steinbruchelstrasse 62, Zurich 7/53, Switzerland. (M)
Bourgeois, James F., Assoc. Producer, Visual Education Films. Mail: 2215 Central St., Evanston, Ill. (A)
Byloff, Robert W., Manager, Systems Engr. Broadcast Div., Radio Corp. of America. Mail: 1 Gwen La., Devon, Pa. (M)

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Cardasis, Peter P., General Office Mgr., Movielab Film Labs. Mail: 131-06 229th St., Laurelton 13, N. Y. (A)
Carlin, Richard J., Film Techn., Consolidated Film Ind. Mail: 6458 Densmore Ave., Van Nuys, Calif. (A)
Carter, P. R., Co. Dir., Provincial Cinemas Ltd., Civic Theatre, Kawerau, Bay of Plenty, N. Z. (A)
Castrignano, Robert A., Eng., Columbia Broadcasting System. Mail: 157 Idlewood Dr., Stamford, Conn. (M)
Chismark, Albert H., Dir. of Eng., WHEN-TV, 101 Court St., Syracuse, N. Y. (M)
Clark, George B., Projectionist, St. James Theatre. Mail: Box 835, Asbury Park, N. J. (M)
Clark, Harold, Manager, Eastern Sound Co. Mail: 308 Maple St., New Market, Ont., Can. (M)
Cochey, Jacob, Dir., Producer, Ramah Films Co. Mail: 40 W. 90 St., New York. (A)
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Cameraman—Motion, Still, Aerial. 7 yrs experience, Navy and civilian school graduate. Experienced in aerial, still, data gathering and motion-picture production photography and equipment. Employed by major aircraft corporation and Cape Canaveral Missile Test Range. Past membership in American Society of Photogrammetry, Active Member of SMPTE. Single, age 27, will relocate. Prefer position as photog. coordinator or motion-picture cameraman with large corporation. 1808 Tower Rd., Glen Burnie, Md.

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Film Production. Talented production executive desires relocation in N.Y.C. area. Experienced in all phases of motion-picture production, particularly industrial, documentary and public relations films. Resume and references supplied on request. Write: Les Miller, Rm 707, 276 Fifth Ave., New York 1. MU 9–1771.

Film Production. Assignment wanted for travel film, news, documentary or educational film. Have three B&H cameras, wide-angle lens to 400 mm, one special camera for slow motion, motor driven, also still cameras and tape recorder. Have shot recent TV series and bird life film for national studio. Made over fifty trips through Central America and six through most of Europe. Will accept assignments to any area. F. Robert Johnston, 278 East 23 St., Costa Mesa, Calif.

Film Salesman-Project Supervisor. Expand your business—rare opportunity to acquire creative man with diversified experience in film promotion, production, distribution. Ivy League grad, 33, personable. Excellent refs. Write: EO, Suite M 18, 314 East 38 St., New York 16.

Motion Picture Laboratory Specialist. Well versed in equipment and procedures. Desires position with a well established organization. For resume write: Charles Stephens, 772 Miami Chapel Rd., Dayton, Ohio.

Director, Cameraman, Editor of nontheatrical films. Experienced in all phases of film production. Was employed by Audio Visual Service USOM/L, c/o American Embassy in Beirut, Lebanon as Program Advisor, Film Production Supervisor. Age 26, married, member of SMPTE, willing to relocate. Resume on request. Write: Hrayr Toukhanian, 3731 Irving St., San Francisco 22.

Motion-Picture Production and Direction. Former Secretary-Treasurer SMPTE Student Chapter CCNY, trained in all phases motion-picture production and directing, desires position with production company with possibility of working up through editing and camera to direction. Age 29, single, willing to relocate Robert F. de Brito, 120 East 31 St., New York 16. MU 5-3060.

Film Writer-Director-Editor with broad administrative, advertising and public relations background. Fully capable of supervising industrial audio-visual department. Screen credits include all types of films from documentary to drama. Know cost control, sound recording, evaluation, equipment. Write Film Director, 4410 Walsh St., Chevy Chase 15, Maryland.

Industrial Photographer, Producer, Director. Desires position with vigorous film production outfit in either production or organization. Will accept heavy project responsibility. Experienced in all phases of motion-picture production and laboratory operations. Thoroughly familiar with military photographic requirements especially in the area of missile R & D. Single, willing to relocate. Resume on request. Write: Avrum M. Fine, 272 West 17th St., Hialeah, Fla.

Positions Available

Photographic Specialist. Require professional for executing photographic assignments in creative application of all available photographic techniques and equipment. Applicant must interpret requirements of those using photo lab facilities. Direct and photograph motion pictures and stills. Direct the work of other photographers and technicians. Send resume to: W. O. Borden, Employment Office, Convair-Astronautics, Cocoa, Fla.

Engineers, Mechanical & Electronic. Experienced in design, production, manufacture of photographic consumer and/or military products and instrumentation. Must be familiar with motion-picture camera and projector design; capable of creative simple design solutions for economical production manufacture; knowledge of dimensioning for parts interchangeability. Opportunity to join reputable engineering staff of progressive, rapidly growing organization. Foto Development Corp., 123 Eileen Way, Syosset, L.I., N.Y.

Designer. Expanding manufacturer needs designer with experience in motion-picture laboratory equipment. Write or call Forway Corp., 245 West 55 St., New York 19. CO 5-0372.

Cinematographer-Editor. Small organization in Chicago area requires capable industrial cameraman for work in 16mm color, combining editing and some still work for sound slidefilms. Man selected must have good college background, married, under 35. Recent grads with good college background in motion picture-TV or cinematography will also be considered. Good income with excellent opportunities for advancement. Please furnish references, salary requirement and qualifications. Address P.O. Box 244, Park Ridge, Ill.

Optical Effects. Exceptional opportunity for responsible young married man (25–35) to embark on motion-picture film career with leading optical effects house. Good health and basic knowledge of still photography required. If you know a career minded ambitious young man who can accept challenging work have him contact Eastern Effects, Inc., 333 West 52nd St. New York 19. CIrcle 5–5280.

Electrical Engineer. Manufacturers of instrumentation cameras currently engaged in enlarging their facilities are looking for a mechanical engineer experienced in the design of motion-picture cameras, optical printers, or related equipment. Write or call for an appointment. Photo-Sonics, Inc., 2704 W. Olive Ave., Burbank, Calif. Attn: Otto Schiff—VIctoria 9-3144.

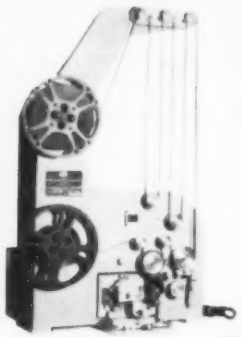
Engineers—Optical, Video Circuitry, TV Systems with training and experience to assume broad project responsibility. These openings afford opportunity to work in advanced mobile and airborne TV areas where individual contributions can range from conceptual realization to proof of feasibility. Please write informally, in complete confidence to: Mr. Joseph Skelly, Box 12, DuMont Research & Development Division, 750 Bloomfield Ave., Clifton, N.J.

Technical Writers. Electronic equipment; familiarity with military specs and government procedure essential. Work in Long Island area. 12 required. **Electronic Engineers,** with TV camera, monitor, closed-circuit design experience. 15 required. Penult Corp., 103-14 Roosevelt Ave., Corona 68, N. Y. HIckory 6-1294.

Photographic Instrumentation Engineer. GS-13, $10,130 per yr. To act as technical rep. of U. S. Army Pictorial Center, N.Y., in working with manufacturers and reps. of other gov. agencies on testing, operation repair, design and supervision of manufacture of electromechanical instrumentation systems based on photographic recording devices. Considerable travel involved. Applicants must have 4 yr engineering college or equivalent college and experience combination, plus 3 yr general and 1 yr specialized engineering experience. Standard Form 57 (Application for Federal Employment), obtainable from the U. S. Civil Service Commission or any Post Office, should be completed and sent to: Civilian Personnel Office, Army Pictorial Center, 35-11 35th Ave., Long Island City 1, N.Y. RA 6-2000, Ext. 238.

Photographic Instrumentation. Los Angeles area firm manufacturing photographic instrumentation equipment needs a sales engineer. Engineering degree preferred. Position consists of selling, training field personnel, field service, and relating customers' requirements to the design of new products. Send resume to P.O. Box 22140, Los Angeles 22, Calif.

Motion-Picture Laboratory Supervisor. Reqire experienced person to supervise operations of small laboratory processing and printing black-and-white as well as printing of color reversal and negative-positive. Responsibility includes quality control, flow of operations, checking and maintenance of equipment as well as instruction of student personnel. Opportunity included for personal study and course work at reduced tuition and University teaching in qualified subjects. Send resume to: Herbert E. Farmer, Dept. of Cinema, Univ. of Southern California, University Park, Los Angeles 7 Calif.



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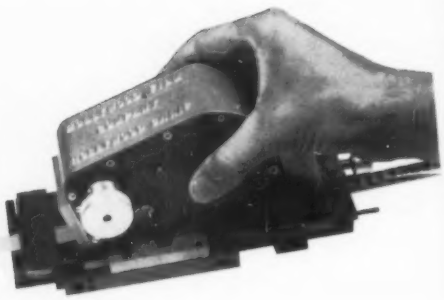

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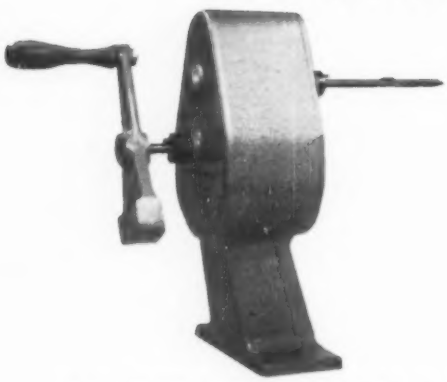

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Meeting Calendar

American Association for Advancement of Science, Annual Meeting, Dec. 26–31, Chicago.
Sixth National Symposium on Reliability and Quality Control, Jan. 11–13, 1960, Statler Hilton Hotel, Washington, D.C.
Institute of the Aeronautical Sciences, Annual Meeting, Jan. 25–28, 1960, Hotel Astor, New York.
AIEE, Winter General Meeting, Jan. 31–Feb. 5, New York.
IRE and AIEE, Transistor and Solid State Circuits Conference, Feb. 11–12, 1960, Univ. of Penn., Philadelphia.
National Society of Professional Engineers, Winter Meeting, Feb. 18–20, 1960, Broadview Hotel, Wichita, Kan.
Deutsche Kinotechnische Gesellschaft, Annual Meeting and Equipment Exhibit, Mar. 1–5, 1960, Technical University, Berlin.
National Electrical Industries Show, Mar. 6–9, 1960, Coliseum, New York.
ASCE, New Orleans Convention, Mar. 7–11, 1960, Jung Hotel, New Orleans, La.
IRE National Convention, Mar. 21–24, 1960, Coliseum and Waldorf-Astoria Hotel, New York.
American Chemical Society, National Meeting, Apr. 5–14, 1960, Cleveland, Ohio.
Optical Society of America, Spring Meeting, Apr. 7–9, 1960, Hotel Statler, Washington, D.C.
Inter-Society Color Council, 29th Annual Meeting, Apr. 11, 12, 1960, Philadelphia Museum College of Art, Philadelphia.
IRE, South West Regional Conference and Electronics Show, Apr. 20–22, 1960, Shamrock-Hilton Hotel, Houston, Texas.
87th Semiannual Convention of the SMPTE, including Equipment Exhibit, May 1–7, 1960. Ambassador Hotel, Los Angeles.
IRE National Aeronautical Electronics Conference, May 2–4, 1960, Dayton, Ohio.
Society of Military Engineers, National Convention, May 16, 17, 1960, Washington, D.C.
ASME, Design Engineering Div. Conference, May 23, 1960, New York.
Design Engineering Show, May 23–26, 1960, Coliseum, New York.
Institute of the Aeronautical Sciences, National Summer Meeting, Mid-June, 1960, Los Angeles.
Acoustical Society of America, Spring Meeting, June 9–11, 1960, Providence, R.I.
National Society of Professional Engineers, Annual Meeting, June 9–11, 1960, Statler Hotel, Boston, Mass.
AIEE, Summer General Meeting, June 19–24, 1960, Atlantic City, N.J.
American Society for Engineering Education, Annual Meeting, June 20–24, 1960, Purdue Univ., West Lafayette, Ind.
American Society for Testing Materials, Annual Meeting and Apparatus Exhibit, June 26–July 1, 1960, Chalfonte-Haddon Hall, Atlantic City, N. J.
AIEE, Pacific General Meeting, Aug. 8–12, 1960, San Diego, Calif.
Fifth International High-Speed Congress and Equipment Exhibit, sponsored by the SMPTE, Oct. 16–22, 1960, Sheraton-Park Hotel, Washington, D.C.
89th Semiannual Convention of the SMPTE, Spring 1961, King Edward Sheraton, Toronto.
90th Semiannual Convention of the SMPTE, Oct. 2–6, 1961, Lake Placid, N. Y.
91st Semiannual Convention of the SMPTE, Apr. 30–May 4, 1962, Ambassador Hotel, Los Angeles.
92d Semiannual Convention of the SMPTE, Oct. 22–26, 1962, Drake Hotel, Chicago.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1959 Journal.

sustaining members

of the Society of Motion Picture and Television Engineers

The objectives of the Society are:

- Advance in the theory and practice of engineering in motion pictures, television and the allied arts and sciences;
- Standardization of equipment and practices employed therein;
- Maintenance of high professional standing among its members;
- Guidance of students and the attainment of high standards of education;
- Dissemination of scientific knowledge by publication.

Progress toward the attainment of these objectives is greatly aided by the financial support provided by the member companies listed below.

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The Society invites applications for Sustaining Membership from other interested companies. Information may be obtained from the Chairman of the Sustaining Membership Committee, Byron Roudabush, c/o Byron Motion Pictures, Inc., 1226 Wisconsin Ave., N.W., Washington 7, D.C.